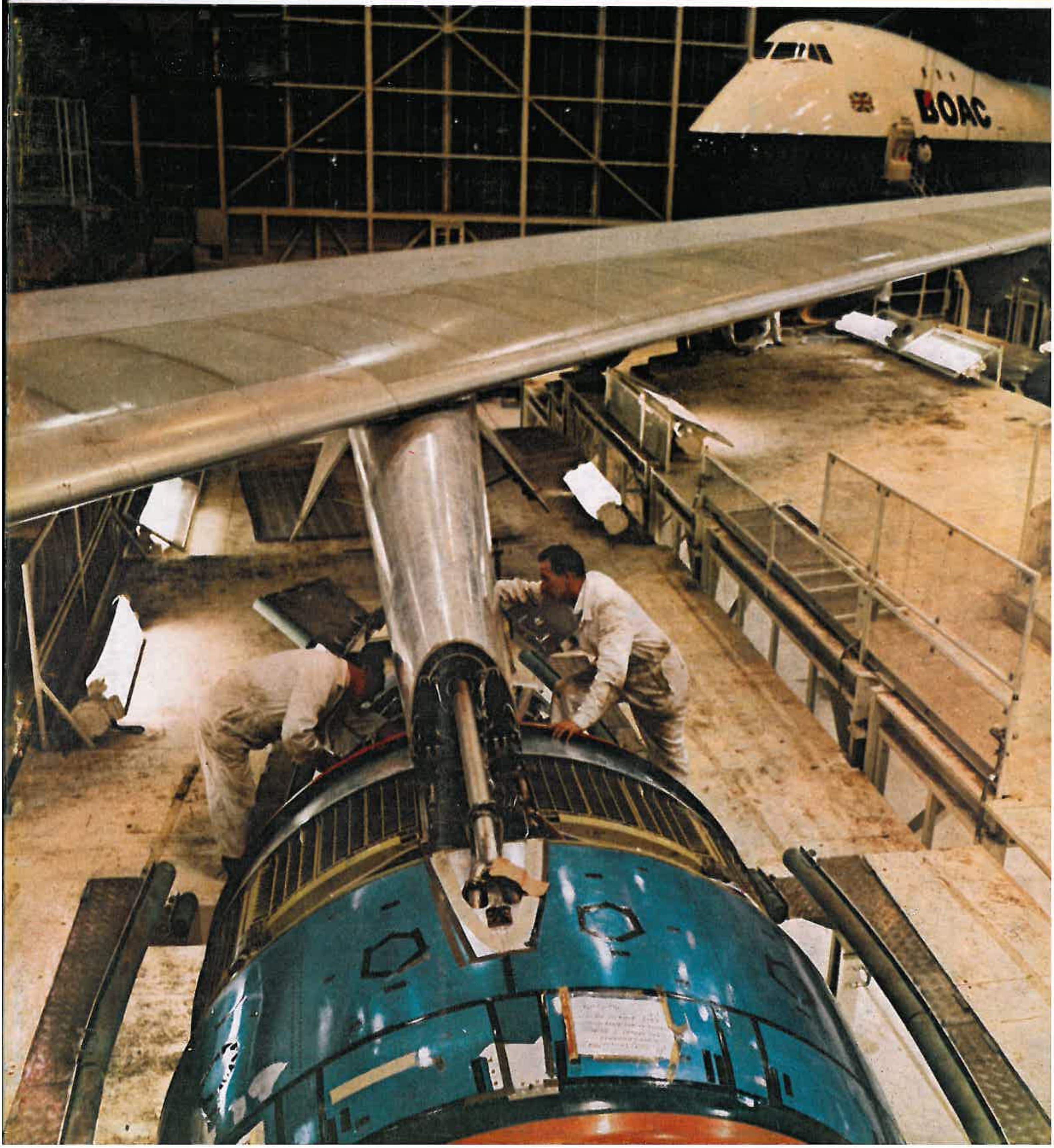
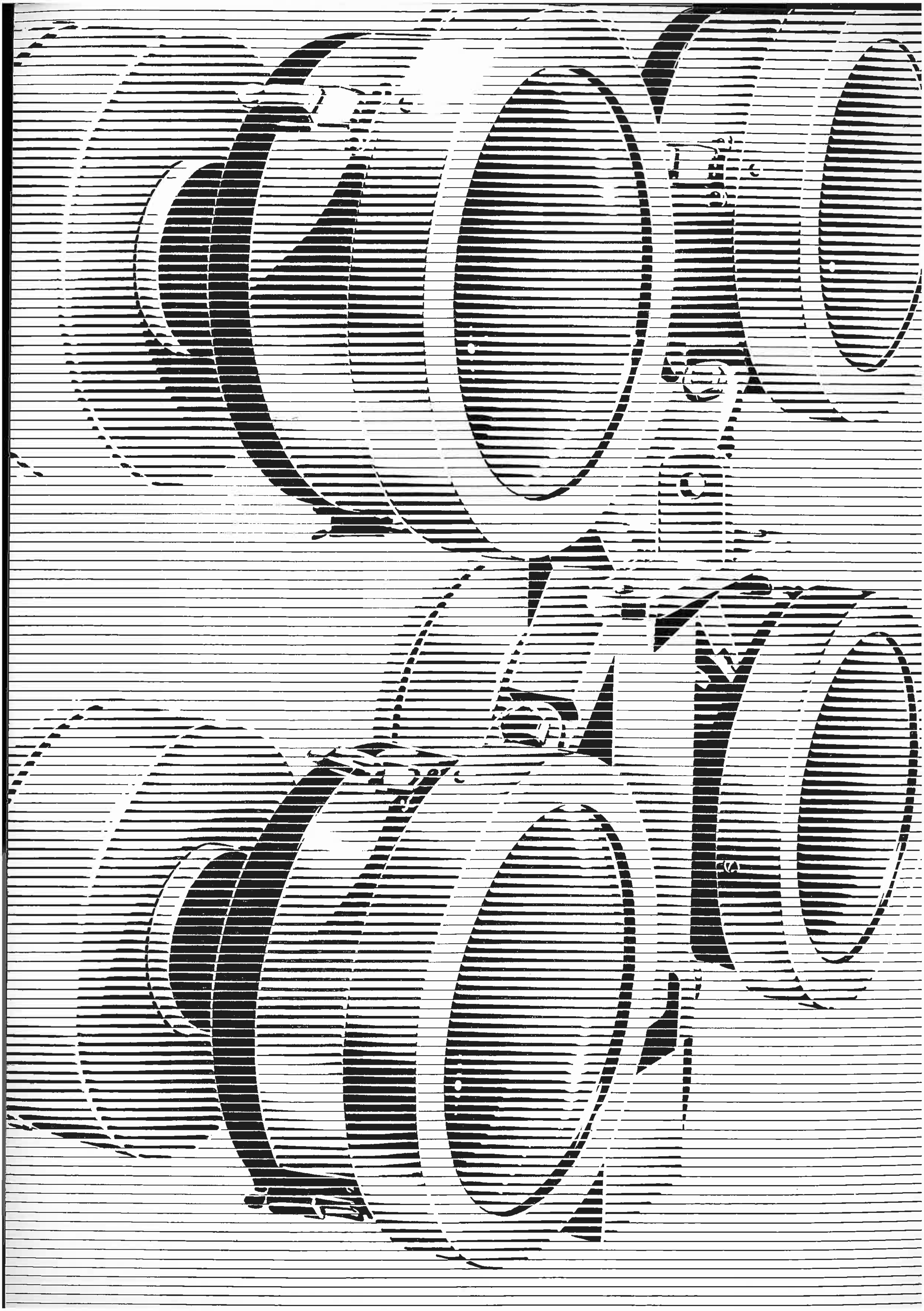
LIGHTING JOURNAL

floodlighting for colour TV
high-bay lighting
linear sources on the motorway

number six/spring 1971/published by THORN LIGHTING LIMITED





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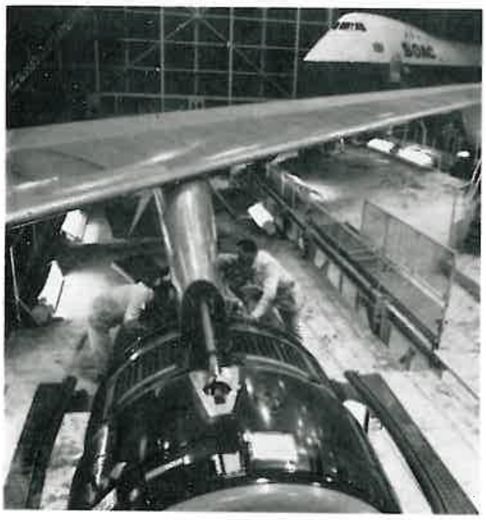
Cover picture shows Atlas Invincible flameproof fittings giving 400 lux in the new jumbo jet hangar at Heathrow—London Airport.



Published by Thorn Lighting Limited
(Atlas Mazda Ediswan lighting products)
Thorn House Upper Saint Martin's Lane
London WC2H 9ED. Printed by Martins Press
Limited London England

A few years ago the majority of people in the lighting industry would have dismissed discharge lamps as suitable only for streets and floodlighting or for a few very specialised applications, such as the use of xenon lamps in cinema projectors. Now a series of startling developments in this field has led to their use in situations where they had never before been seen and it seems that we are again in a period of rapid expansion such as marked the introduction of fluorescent lamps. This issue of *Lighting Journal* is concerned mainly with these new lamps and the techniques resulting from their use. Of special interest are the compact source mercury iodide lamps which bid fair to revolutionise sports and stadium lighting in the next few years. Here the advent of colour television, requiring far more light of an acceptable colour than could economically be provided by incandescent lamps, has acted as a spur.

It is in the field of colour rendition however that the most spectacular progress has been made. The use of new phosphors in mercury fluorescent lamps and the addition of certain halides to the mercury arc have brought about such improvements that these lamps now rival fluorescent tubes. Indeed, their compact size and high loading often give them the advantage even in commercial lighting installations. In the sodium field, in addition to the prodigious increases in efficacy resulting from the development of linear sources, the high pressure lamp allows a range of colours to be easily distinguished. This issue also includes an article on the appraisal of lighting installations, a technique which owes much to work done by the present President of the Illuminating Engineering Society, Mr. Harry Hewitt, who was founder editor of this journal.

profile: Harry Hewitt CEng FIEE FIllumES

Harry Hewitt is a Lancastrian. Born in Wigan and educated at Salford Grammar School, he has the forthright charm which distinguishes many of the sons of the White Rose. After graduating from the Royal Technical College, Salford, he started his career in the electric supply industry in the Swinton and Pendlebury Electricity Department in 1926. He joined Siemens in 1938 and during this period became locally famous as an actor, taking part in BBC programmes for some years. He has always been a very active member of the IES and, after joining the staff of the North Western Electricity Board in 1950, published a paper on lighting in the textile industry which was not only notable for its contents but, what is much rarer, for the excellence of its presentation.

In 1953 he came to Atlas Lighting as assistant technical sales manager and is one of that little galaxy of stars who have contributed so much to the company's success. He has been in charge of lighting research at the Enfield laboratories and is now manager of the Thorn-Benham Environmental Unit.

Mr. Hewitt has two books to his credit, *Modern Lighting Technique* and *Lamps and Lighting* in which he was co-editor with Mr. A Vause. He has been involved in almost all recent developments in lighting and is specially noted for the pioneer work he has done in the appraisal of lighting schemes and in the field of environmental engineering. He has presented papers at national lighting conferences in the UK, the USA, Australia and South Africa. As President of the IES, he is a worthy successor of Dr. John Strange and Dr. Harold Ballin, members of the Thorn organisation who preceded him in that office.

dans cette édition

2 PROFIL. Harry Hewitt.

Harry Hewitt est un homme du Lancaster. Né à Wigan et éduqué à l'Ecole de Salford, il a le charme qui distingue beaucoup les enfants de la "White Rose". Après son diplôme du Lycée Technique Royal de Salford, il a commencé sa carrière à la Division Electricité de la Société Swinton et Pendlebury en 1926. Il entre chez Siemens en 1938 et, pendant cette période, acquiert une très bonne réputation locale d'acteur, participant aux programmes de la BBC pendant quelques années. Il a toujours été un membre très actif de l'IES et, après avoir rejoint la Direction de la "North Western Electricity" en 1950, il publie un article sur l'éclairage de l'industrie textile qui n'était pas seulement remarquable par son contenu mais, ce qui est plus rare, pour l'excellence de sa présentation.
En 1953, il entre chez Atlas Lighting Ltd. comme Chef de Ventes Technico-Commercial Adjoint et il est l'un de cette petite galaxie d'étoiles qui ont tellement contribué au succès de la Compagnie. Il a été responsable de la recherche en éclairage aux Laboratoires d'Enfield et il est maintenant Directeur de Thorn Benham Environmental Unit.
Mr. Hewitt a écrit deux livres, "Technique Moderne de l'Eclairage" et "Lampes et Eclairage" qu'il a écrits en collaboration avec Mr. A. Vause. Il a été impliqué dans presque tous les développements techniques récents en matière d'éclairage et il faut noter particulièrement son travail de pionnier dans le domaine des études d'éclairage et dans celui des études de l'Engineering d'environnement de l'éclairage. Il a présenté de nombreuses thèses à des conférences nationales d'éclairage à la fois en Grande-Bretagne, aux Etats-Unis, en Australie et en Afrique du Sud. Comme Président de l'IES, il est un digne successeur du Dr. Strange et du Dr. Ballin, membres de l'Organisation Thorn qui l'ont précédé dans cette fonction.

5 . . . MAIS JE SAIS CE QUE J'AIME. *par* **Dr. A. M. Marsden, L'auteur est le Chef de Service des Laboratories de Recherches et de Développement de Thorn Lighting Ltd.**

La plupart des gens jugent les appareils d'éclairage d'après leur apparence, mais leur fonction réelle est de retransmettre la lumière là où elle est nécessaire. Le problème fondamental dans toute recherche d'éclairage est de déterminer une distribution acceptable de la lumière dans un environnement donné. Ce problème ne peut être résolu qu'en notant les réactions des gens dans un environnement contrôlé.
Pendant les dix dernières années, ces sortes de préoccupations se sont déplacées des Laboratoires de Recherches au profit des études sur le terrain de la mesure objective aux préférences subjectives. Il a découlé de cela une technique d'appréciation permettant d'évaluer l'éclairage intérieur et, en même temps, l'éclairage extérieur. Une récente série d'approches d'éclairage public à Birmingham, Copenhague et Amsterdam peut être spécialement précieuse pour la rédaction d'un guide international de l'éclairage public.
Les questionnaires utilisés au cours de l'étude incluent des questions sur la lumière du jour, sur le mobilier et la décoration de la pièce aussi bien que des questions ayant trait spécialement à l'éclairage artificiel. Leur intérêt pour aiguiser les facultés critiques des ingénieurs-éclairagistes est maintenant bien établi mais il est trop tôt encore pour dire combien cette technique affectera la pratique de l'éclairage dans l'avenir.
Dans la technique sémantique différentielle introduite dans nos Laboratoires d'Enfield l'année dernière, on demande à l'observateur d'évaluer son impression visuelle sur un endroit donné sur une échelle de valeur à sept points utilisant 20 critères différents : de laid à beau, d'amical à inamical, de chaud à froid etc. Ce genre d'exercice demande une fourniture considérable de donnees, et du fait de la nécessité de faire venir une quantité considérable de gens en un seul endroit, il est difficile de l'organiser. On se sert maintenant de plus en plus de la technique photographique pour surmonter cette difficulté et des machines électroniques sont utilisées pour exploiter les résultats des tests.

10 ECLAIRAGE D'UN STADE DE FOOTBALL POUR LA TELEVISION EN COULEUR. *par* **R. C. Aldworth et E J. G. Beeson. Les auteurs sont respectivement Ingénieur en Chef et Chef du Service Développement Lampes Spéciales de Thorn Lighting Ltd.**

L'éclairage d'un Stade de Football n'est pas nouveau mais les besoins de la Télévision en Couleur nécessitent une illumination atteignant jusqu'à dix fois les valeurs courantes. Etant donné que la majorité des clubs doivent utiliser les installations de mâts existantes, ou, si l'éclairage de côté est préféré, monter l'équipement sur les tribunes existantes; les considérations de taille, de poids et d'efficacité lumineuse deviennent extrêmement importantes.
Il a été de pratique commune de mesurer l'illumination horizontale sur le terrain. La Télévision nécessite des mesures sur un plan perpendiculaire à l'axe de la caméra qui est habituellement standardisé à un angle moyen de 15° par rapport à la verticale. Cette illumination qu'on appelle usuellement E.15 est approximativement la moitié de l'illumination horizontale à partir d'un mât d'angle, et est environ égale à l'illumination horizontale de projecteurs montés sur le côté.
Des sources lumineuses très compactes de haut rendement et d'un bon rendu de couleur sont nécessaires pour fournir un faisceau contrôlé avec le minimum de perte de lumière et pour réduire l'éblouissement des spectateurs et des caméras de télévision. Deux nouvelles sources, l'une, la lampe CSI scellée à l'intérieur d'un réflecteur parabolique, l'autre, une lampe linéaire mercure aux halogénures ont été développées pour être utilisées respectivement sur des mâts élevés et sur des installations latérales. Ces lampes permettent l'utilisation d'un équipement compact et léger.
Deux installations utilisant ces nouvelles lampes et cet équipement ont été récemment réalisées à West Ham (Installation sur mât d'angle) et à Arsenal (installation d'éclairage de côté montée sur le toit des Tribunes). Dans les deux cas des résultats très satisfaisants ont été atteints.

17 COULEUR ET INTENSITE LUMINEUSE ELEVEE DES LAMPES A DECHARGE. *par* **K. Scott et E. J. G. Beeson. Les auteurs sont respectivement Chef du Service Engineering lampes à décharge et Chef du Service Développement Lampes Spéciales de Thorn Lighting Ltd.**

Le rendu de couleur d'une source lumineuse dépend de sa courbe de distribution spectrale. Alors que la lumière du jour naturelle, des lampes à incandescence et des arcs Xenon ont des spectres continus, la plupart des lampes à décharge émettent de l'énergie selon des bandes discontinues avec, par conséquent, des distorsions de couleur.
Des améliorations du rendu de couleur des lampes à décharge à haute pression de mercure ont été apportées par l'utilisation de poudres fluorescentes ou par l'addition d'un filament de tungstène en série avec le tube à décharge, et au cours des dernières années, l'utilisation de Vanadate d'Yttrium a beaucoup amélioré le rendu de couleur de ces deux types de lampes. Tout récemment l'introduction d'halogénures métalliques dans l'arc de mercure a ouvert de remarquables possibilités. L'accroissement de la pression et de la charge de vapeur a engendré un rendu de couleur comparable à celui des lampes à spectre continu en même temps qu'une réduction de la taille de la source lumineuse, permettant ainsi un contrôle très précis de la lumière. L'accroissement de la pression de vapeur dans les lampes sodium a aussi beaucoup contribué à améliorer le rendu de ces sources.
Etant donné que le rendu de couleur et l'apparence des couleurs d'une lampe à décharge ne sont pas nécessairement liés, il est erroné de les décrire par leur température de couleur apparente, leurs coordonnées X et Y sur un diagramme de chromaticité définissent bien l'apparence de couleur mais le rendu de couleur est beaucoup mieux défini par l'usage d'hystogrammes.

20 ECLAIRAGE DE GRANDES HAUTEURS *par* **D.Wilkinson. L'auteur est Ingénieur en Chef de Thorn Lighting à Belfast.**

Bien que les lampes à décharge aient été longtemps utilisées pour l'éclairage de grandes hauteurs, dans les usines, les lampes à incandescence étaient nécessaires là où un bon rendu de couleur était demandé. L'introduction des lampes à décharge avec un rendu de couleur amélioré, en particulier les Kolorlux et Kolorarc, a rendu les lampes à incandescence complètement périmées pour cette application.
Les avantages de ces lampes à décharge sont la température basse à laquelle elles peuvent s'allumer (jusqu'à —35°C sur un voltage de 85% seulement de la normale), la résistance aux vibrations et la longue durée du fait de la construction robuste des électrodes. La compacité de la source réduit le nombre de points lumineux nécessaires et rend l'aspect des installations plus agréable. Là où ces appareils sont utilisés à des hauteurs moins hautes, ils fournissent un éclairage de haute intensité avec le minimum d'éblouissement.
Les problèmes concernant cette lampe ont été très exagérés. Bien que cela prenne environ cinq minutes pour atteindre le niveau d'éclairement maximum, 20% de l'intensité maximum sont disponibles dans les deux minutes qui suivent l'allumage; leur délai de ré-allumage est moins incommode qu'il le semble puisque les baisses de tension importantes sont rares, et que les installations industrielles sont rarement éteintes pendant l'utilisation. Le danger de mauvaise isolation entre les lampes et le ballast est facilement surmonté par l'utilisation d'un câble correct.
En plus de leurs utilisations traditionnelles dans l'industrie, les appareils d'éclairage pour grandes hauteurs ont de nombreuses applications commerciales, et les excellentes propriétés de rendu de couleur de la lampe Kolorarc en particulier la rendent spécialement précieuse dans les endroits tels que les piscines ou les gymnases. La vitesse d'amélioration technique des lampes à décharge à haute pression est plus rapide que celle de n'importe quel autre type de lampe et l'on peut raisonnablement supposer que ces améliorations améneront une augmentation considérable de leur utilisation dans l'avenir.

24 LAMPE SODIUM LINEAIRE POUR L'ECLAIRAGE AUTOROUTIER. *par* **P. D. Gunnell, Chef du Service des Projets d'Eclairage Extérieur Thorn Lighting Ltd.**

Les affectations de fonds gouvernementaux pour l'éclairage routier et autoroutier sont basées sur une analyse de coût de chaque projet rapprochant la réduction estimée des accidents et le coût de fonctionnement de l'installation. Le projet d'installation est basé sur le code B.S. pratiqué pour les grandes routes, mais étant donné que ceci ne recouvre pas les autoroutes, le Ministère de l'Environnement a établi une nouvelle spécification.
La lampe linéaire de 140W, bien qu'elle soit adaptée pour les grandes routes, ne satisfait pas aux besoins des autoroutes aux surfaces de couleur plus sombre que le béton. Par conséquent, une nouvelle lanterne a été fabriquée pour s'adapter à la lampe de 200W.
Le dessus de la lanterne en plastique renforcé de verre et le système optique en plastique sont maintenus par un fond en aluminium coulé sous pression qui peut aussi contenir le ballast si nécessaire. De ce fait, le poids total de la lanterne est très réduit et les dépenses de maintenance (telles que la peinture) sont abaissées.
Les caractéristiques d'allumage de la lampe 140W permettent l'utilisation d'un courant de 530V, réduisant la taille du câble d'alimentation, ce qui est un aspect important en matière d'éclairage autoroutier puisque tous les facteurs économiques et pas seulement le rendement de la lampe doivent être pris en considération lorsque l'on apprécie l'intérêt d'une installation.

in dieser ausgabe

2 KURZBIOGRAPHIE. Harry Hewitt.

Harry Hewitt stammt aus Lancaster. Geboren in Wigan und ausgebildet an der Höheren Schule in Salford, besitzt er den ehrlichen Charme, der viele der Söhne der White Rose auszeichnet. Nachdem er sein Abschlußexamen an der Königlich Technischen Hochschule, Salford, gemacht hatte, begann er 1926 seine Laufbahn in der Stromversorgungs-Industrie in Swinton und Pendlebury. 1938 schloß er sich Siemens an und wurde während dieser Zeit auch als Schauspieler bekannt. Er wirkte einige Jahre in BBC-Programmen mit. Er ist immer ein sehr aktives Mitglied des IES gewesen, und veröffentlichte, nachdem er 1950 bei dem North Western Electricity Board tätig war, eine Zeitung über Beleuchtung in der Textil-Industrie, welche nicht nur wegen ihres Inhaltes bemerkenswert war, sondern—was viel seltener ist—wegen ihrer vortrefflichen Ausführung.
1953 begann er als Assistent des Technical Manager bei Atlas Lighting Ltd. und ist dort einer des erlesenen Stabs, der sehr viel zum Erfolg der Firma beigetragen hat. Er war verantwortlich für die Beleuchtungs-Forschung der Enfield-Laboratorien und ist nun Manager bei Thorn Benham Environmental Unit.
Zwei Bücher brachten Harry Hewitt großen Erfolg, und zwar "Moderne Beleuchtungstechnik" und "Lampen und Beleucntung". Hier war er zusammen mit Herrn A. Vause der Herausgeber. Er war an fast allen modernen Entwicklungen der Beleuchtung beteiligt und ist besonders angesehen wegen seiner Pioniersarbeit, die er in der Bewertung von Beleuchtungsplänen und auf dem Gebiet der Umwelt-Technik geleistet hat. Auf nationalen Beleuchtungskonferenzen in England, USA, Australien und Südafrika hat er Abhandlungen vorgelegt. Als Präsident der IES (Illuminating Engineering Society) ist er ein würdiger Nachfolger von Dr. Strange und Dr. Ballin, Mitgliedern der Thorn-Organisation, die ihm in diesem Amt vorangingen.

5 . . . ABER ICH WEIß, WAS MIR GEFÄLLT. *von* **Dr. A. M. Marsden, Leiter des Entwicklungslaboratoriums für Licht von Thorn Lighting Ltd.**

Die meisten Menschen beurteilen Leuchten nach ihrem Aussehen, doch ihre eigentliche Funktion ist es, Licht dorthin zu lenken, wo es benötigt wird. Das grundlegende Problem in der Beleuchtungsforschung ist, eine angemessene Lichtverteilung für eine besondere Umgebung zu schaffen. Dieses Problem kann man nur lösen, wenn man die Reaktionen der Menschen in einer kontrollierten Umgebung beobachtet.
Während der letzten zehn Jahre hat sich die Betonung von Laboruntersuchungen zu Gebietserforschung und Messung auf subjektive Vorgänge verschoben. Daraus hat sich die Bewertungstechnik entwickelt, die die Innen- und Außenbeleuchtung bewerten soll. So hat man kürzlich in Birmingham, Kopenhagen und Amsterdam Straßenbeleuchtungs-Bewertungen durchgeführt, die besonders wertvoll für die Erstellung von internationalen Richtlinien der Straßenbeleuchtung sein könnten.
Die Fragebögen für die Bewertungsübungen enthalten Fragen nach der Tageslichtbeleuchtung, der Einrichtung und Ausstattung eines Raumes, sowie solche, die sich besonders auf künstliche Beleuchtung beziehen. Ihr Aussagewert vom Standpunkt des Lichtingenieurs ist anerkannt, jedoch ist es noch zu früh zu sagen, inwieweit in Zukunft die Beleuchtungstechnik davon beeinflußt wird.
In der semantischen Differential-Technik, die letztes Jahr in Enfield erstmals vorgestellt wurde, wird dem Beobachter die Aufgabe gestellt, seinen visuellen Eindruck in einer 7-Punkte-Skala über zwanzig verschiedene Darstellungen hinweg abzugeben—von häßlich bis schön, freundlich bis unfreundlich, warm bis kalt usw.
Diese Art Aufgabe erfordert eine beträchtliche Datenverarbeitung, und da es hierfür erforderlich ist, eine große Anzahl von Personen zu befragen, ist diese Aufgabe sehr schwer. Um diese Schwierigkeit zu überwinden, wird jetzt eine fotografische Technik angewendet, und Computer sind damit beschäftigt, die Ergebnisse dieser Tests auszuwerten.

10 FUßBALLSTADION-FLUTLICHT FÜR FARBFERNSEHEN. *von* **R. C. Aldworth und E. J. G. Beeson, Chef-Ingenieur und Leiter der Lampenentwicklung von Thorn Lighting Ltd.**

Fußballstadion-Flutlicht ist nicht neu, aber die Erfordernisse des Farbfernsehens machen eine Beleuchtungsstärke bis zum zehnfachen der gegenwärtigen Werte erforderlich. Seitdem die Mehrheit der Klubs die bestehenden Flutlichtmaste benutzen muß, oder wenn seitliche Anstrahlung vorgezogen wird, wobei man die Flutlichtgeräte auf bestehende Tribünen montiert, werden Überlegungen über Größe, Gewicht und Leistungsfähigkeit außerordentlich wichtig.
Es war allgemein üblich, die horizontale Beleuchtungsstärke auf der Spielfläche zu messen. Das Fernsehen erfordert die Messung auf einer Fläche zu der Kameraachse, die gewöhnlich um 15° zu der Vertikalen geneigt ist. Diese Beleuchtungsstärke, auf die man sich gewöhnlich als E 15 bezieht, ist ungefähr die halbe horizontale Beleuchtungsstärke von einer Eckmast-installation und ungefähr gleich der von seitlich montierten Flutlichtstrahlern.
Um ein gut kontrollierbares Lichtbündel mit einem Minimum an Lichtverlust zu erlangen und die Blendung für Zuschauer und Fernsehkameras zu reduzieren, werden sehr kompakte Lichtquellen mit hoher Leistungsfähigkeit und guter Farbwiedergabe benötigt. Zwei neue Lichtquellen sind für die Anwendung auf Masten und bei Seitenmontage geschaffen worden. Die eine ist eine CSI-Lampe in einem Parabolreflektor, und die andere eine stabförmige Metall Halogen-Dampflampe. Diese Lampen erlauben den Einbau in kompakte und leichte Strahlergehäuse.
Kürzlich sind zwei Installationen fertiggestellt worden, die diese neuen Lampen und Ausrüstung verwenden; die eine in West Ham (Mastinstallation) und die andere in Arsenal (Seitenmontage-Beleuchtung auf dem Dach der Tribünen). In beiden Fällen konnten sehr zufriedenstellende Resultate erzielt werden.

17 FARBE UND HOCHLEISTUNGS-ENTLADUNGSLAMPEN. *von* **K. Scott und E. J. G. Beeson, Leiter der Abteilung Entladungslampen und Lampenentwicklung von Thorn Lighting Ltd.**

Die Farbwiedergabe einer Lichtquelle hängt von ihrer spektralen Lichtverteilung ab. Während natürliches Tageslicht Glühlampen und Xenon Entladungen ein kontinuierliches Spektrum besitzen, strahlen die meisten Entladungslampen ein Linienspektrum bei scharfer Farbtrennung aus.
Durch die Verwendung von Leuchtstoffen oder der Zuschaltung eines Wolframfadens in Reihe mit der Entladungsröhre konnten Fortschritte in der Farbwiedergabe von Quecksilberdampf-Hochdruck-Entladungslampen gemacht werden. Auch die Anwendung von Yttrium Vanadate hat in den letzten Jahren die Farbwiedergabe dieser beiden Lampentypen sehr verbessert. Noch kürzlich hat die Zugabe von Metall Halogenen in die Quecksilberentladung außergewöhnliche Möglichkeiten eröffnet. Weitere Erhöhung des Dampfdruckes und der Belastung haben eine Farbwiedergabe ergeben, die vergleichbar ist mit der von Lampen mit kontinuierlichem Spektrum. Auch die Größe der Lichtquelle wurde reduziert, wodurch eine genaue Kontrolle des Lichtbündels ermöglicht wurde.
Seitdem Farbwiedergabe und Lichtfarbe einer Entladungslichtquelle nicht zwangsläufig zusammenhängen, ist es irreführend sie mit ihrer scheinbaren Farbtemperatur zu bezeichnen. Ihre X-Y Koordinaten auf einer Farbtafel werden ihre Lichtfarbe eindeutig festlegen, aber die Farbwiedergabe kann bei Anwendung des Hystograms besser geschätzt werden.

20 INDUSTRIE-REFLEKTORLEUCHTEN. *von* **D. Wilkinson, Chef-Ingenieur von Thorn Lighting nach Belfast.**

Obgleich Spezial-Entladungslampen für IR-Leuchten in der Industrie bereits seit langem verwandt werden, wurden für gute Farbwiedergabe immer noch Glühlampen benötigt. Die Verbesserung der Spezial-Entladungslampen in bezug auf Farbwiedergabe, speziell bei der Kolorlux- und Kolorarc-Lampe hat die Glühlampe für obige Verwendungszwecke absolut unnötig gemacht.
Vorteile dieser Spezial-Entladungslampen sind niedrige Starttemperatur (bis zu —35°C bei 85% der Nennspannung) Stoßfestigkeit und lange Lebensdauer auf Grund der stabilen Elektroden-Konstruktion. Die konzentrierte Lichtquelle gestattet eine geringere Anzahl von Lichtpunkten und günstige Beleuchtungsmöglichkeiten. Wo diese Leuchten in geringen Höhen montiert werden, werden hohe Beleuchtungsstärken mit geringer Blendung erzielt.
Anfangsschwierigkeiten mit der Lampe sind überwunden. Obgleich die Anlaufzeit ca. 5 Minuten beträgt, werden 20% der maximalen Lichtausbeute nach 2 Minuten erreicht. Die Nachteile der Wiederzündung sind nicht so gravierend als man denkt, da Ausfälle der Versorgungsspannung und Abschaltungen in der Industrie äußerst selten sind. Die Möglichkeit der Isolationsdefekte an der Leuchtenverdrahtung sind durch Wahl des richtigen Kabels auszuschalten.
Zusätzlich zur bisherigen Verwendung in der Industrie finden diese Reflektorleuchten eine Reihe von neuen wirtschaftlichen Verwendungsmöglichkeiten. So ist wegen der besonders guten Farbwiedergabe der Kolorarc-Lampe eine Anwendung z.B. auch in Turnhallen und Schwimmbädern gegeben. Der Grad der Verbesserung bei den Hochdruckentladungslampen ist weit höher als bei jeder anderen Lampe, und es ist sicher anzunehmen, daß diese Weiterentwicklung ihre Bedeutung in der Zukunft vergrößern wird.

24 LINEARE NATRIUM-LAMPE FÜR DIE AUTOBAHN-BELEUCHTUNG. *von* **P. D. Gunnell, Leiter für Projekte für Straßenbeleuchtung.** *von* **Thorn Lighting Ltd.**

Zuweisungen des Staates an Geldmitteln für Straßen- und Autobahn-Beleuchtung basieren auf einer Kostenanalyse eines jeden Entwurfs, wobei die veranschlagte Reduzierung von Unfällen in Beziehung zu den Betriebskosten der Beleuchtung gebracht wird. Die Berechnungen basieren auf den B.S.-Vorschriften für Fernstraßen. Da diese keine Autobahnen einschließen, wurde von der Abteilung "Umwelteinflüsse" eine neue Spezifizierung ausgearbeitet.
Die 140 W lineare Lampe würde, obwohl sie für Fernstraßen ausreichend ist, nicht den Erfordernissen der Autobahnen entsprechen, deren Oberflächen dunkler in der Farbe sind als Beton. Folglich ist eine neue Leuchte entworfen worden, die die 200 W Lampe aufnehmen soll.
Ein glasverstärktes Plastikgehäuse und das optische System aus Plastik werden zwischen Aluminium-Spritzguß-Seitenteile montiert, welches auch—wenn nötig—das Vorschaltgerät aufnehmen kann. Bei dieser Bauart ist das Gewicht der Leuchte stark reduziert, und die Instandhaltungskosten (Streichen usw.) sind niedriger.
Die Anlaufkurven der 140 W Lampe gestatten den Gebrauch einer 530 V Zuleitung und reduzieren den Durchmesser der Zuleitungskabel, welches eine wichtige Überlegung in der Autobahn-Beleuchtung ist, seitdem alle wirtschaftlichen Faktoren und nicht allein die Leistungsfähigkeit der Lampe in Erwägung gezogen werden müssen, um eine Anlage zu bewerten.

. . . but I know what I like

by A M Marsden MSc PhD CEng MIEE FIllumES

Lighting for most of us implies table lamps with lamp shades, fittings mounted on the ceilings or the walls of our rooms, lanterns on columns along our roads. We have come to accept these luminaires as part of our interior or exterior furnishings and, as such, to judge them by their appearance. Such judgments are mainly aesthetic, a matter of taste, perhaps a matter of fashion. They are important, but history suggests that appearance judgments do not form a profitable issue for experimental research.

A luminaire is more than just a pretty face: it has to redirect light from the lamp it contains to where the light is needed and where the light is wanted. Light is needed on this page you are reading and it is wanted on the other surfaces that make up the environment you are occupying: in reaching the page and the surfaces it flows across space and reveals there the people and the objects which are sharing your environment. So as well as having sculptural qualities which may or may not be acceptable, a luminaire can be judged on how well it works with its fellows in distributing light around its environment.

The fundamental question

The fundamental question, which has inspired and is still inspiring the majority of lighting research, is "What is an acceptable distribution of light in a particular environment?" It is possible to break this fundamental question down into a long series of smaller ones, unfortunately interacting—How much light should be provided where critical seeing takes place and from which direction should it come? How much light should be provided on the near surrounds and on distant surrounds? What directionality is desirable for revealing the three-dimensional nature of objects? Should there be a limit on luminaire brightness? etc., etc.

To find answers to such questions as these requires that people be inserted into an environment and their reactions noted. Some of the questions require measurements on subjective performance, some a statement of subjective preference. Controlled environments have been created in laboratories for some tests; other work has been carried out by means of field studies.

During the last ten years the emphasis has been on subjective preference rather than performance measures, on field studies rather than on laboratory exercises. This is not to deny the value of current work such as that in the United States on visual performance or the laboratory studies in Britain on modelling and on luminance distribution. In fact, as many if not more lighting design criteria have emerged during this period from laboratory studies as from field studies, although most are tentative criteria which will require field validation.

The technique of appraisal

Of special significance in the area of field preference studies has been the evolution of the technique of appraisal. In 1964 the President of the Illuminating Engineering Society (John Strange) urged the society to look critically at its lighting installations and to "draw a line around the look". This piquant phrase, used first by a small boy des-

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cribing how he sketched things, summarizes appraisal. Subjects are obliged to look, to look hard enough and critically enough to be able to do something about their look—to answer specific questions about what they see. Given the right questions, aggregated answers will describe the subjective effect of the lighting system, or the environment, or perhaps the interaction of the two. The acceptability or otherwise of a lighting system can clearly be assessed by such an exercise: it is not beyond the bounds of possibility that the accumulated findings of such exercises could suggest new lighting design criteria and some appraisal exercises have been conducted with this end in view.

The technique of appraisal has hit the lighting headlines when applied to the interior environment, but a recent series of exercises concerned with the lighting of traffic routes is perhaps the best way to introduce the art.

A streetlighting exercise

One afternoon last December 50 observers, mainly British but with several continental countries represented, assembled at Birmingham University to have an appraisal exercise explained. They were to drive after dark along a 40-mile circuit stretching north-west to Wolverhampton at a speed appropriate to local traffic and weather conditions. In following the route 38 specified streetlighting installations were to be encountered: these were identified on a route map with a written description. The route included class A roads of varying importance, motorways and urban ringways: the installations used mercury or sodium lighting with cut-off, semi-cut-off or unclassified distributions of varying vintage.

Came the dark and, two in a car, the observers departed on their mission. As each specified lighting installation was approached the passenger told the driver the type of road involved and the length and type of installation lighting it. The passenger then silently recorded on nine-point scales the degree of satisfaction he experienced with (a) the road brightness, (b) the uniformity of brightness, (c) the limitation of glare, (d) the visual guidance provided and (e) the visibility. Having recorded his own impression he then asked the driver for his assessment of the lighting under these same five headings and recorded the driver's verdict.

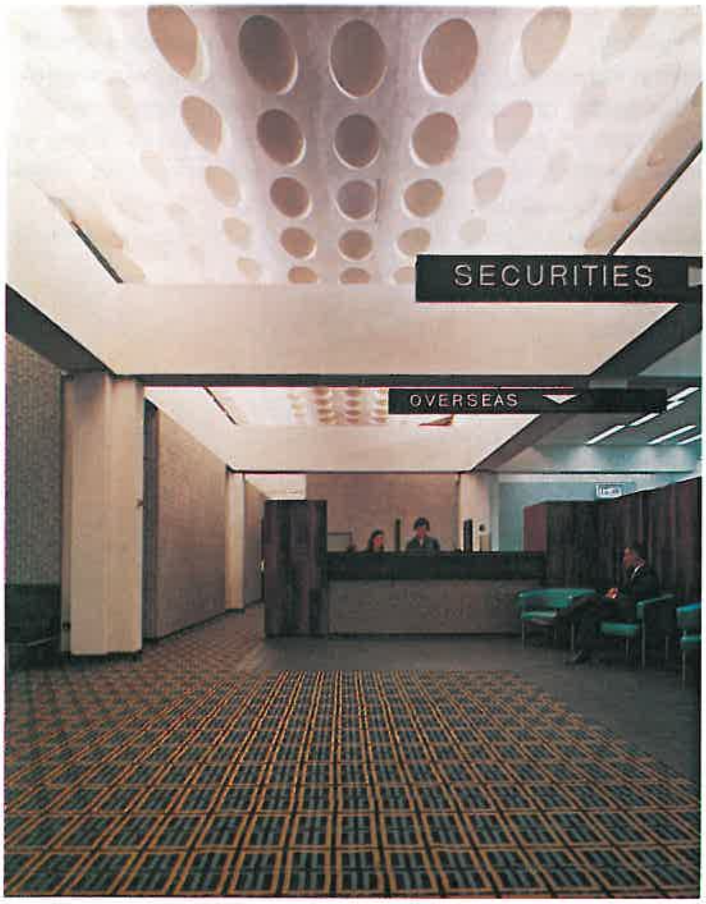
Some 400 assessments and two or three hours later each pair of observers returned to hand in their appraisal forms, which also provided the organisers with personal details of the observers—age, visual defects, occupation, country of residence, driving experience.

While the appraisers retired to bed, two noble Dutch and one English lighting men set off on a much slower drive round the circuit with measuring instruments to record the road luminances under all the installations. These luminance measurements, together with previously obtained plans of installation geometry and lantern characteristics, formed the physical or objective measures of the lighting installations.

Main subject of work

The analysis of this data will take some time, as will that for similar appraisals held during the same month in Copenhagen and Amsterdam. What it is hoped will emerge is some correlation between the acceptability of road brightness and the average luminance measured, between the acceptability of uniformity and some measure of luminance diversity, between the acceptability of glare limitation and some measure of disability or discomfort glare.

The main object of the work is the confirmation or denial of some tentative recommendations for these three parameters proposed for



At the High Holborn branch of the National Westminster Bank in London lighting designed for the well-being of staff and customers achieved and sometimes exceeded the target set by its designers. Basic lighting is from 6ft x 6in diffuser fittings purpose made by Thorn Lighting to fit in the cast plaster ceiling.
PAR 38 'wall-washers' light the back wall and 500W Sunfloods provide indirect lighting of the curved ceiling.

an international guide to streetlighting. The subject of glare is the most interesting of the three: the results will be examined to see whether there is any significant difference in the sensitivity to glare from streetlighting between British and continental observers, which could be possible in view of certain differences in streetlighting practice. Visual guidance is a matter on which little subjective data exists, so here there is a search for a criterion as opposed to attempted validation. Visibility satisfaction may be related to more than just a compounding of level, uniformity and glare limitation: this will be examined in the appraisal results, particular attention being given to the lighting of areas adjoining the carriageway.

Appraisals of interior

Appraisals of the interior environment have been more to the fore in British lighting circles than exterior appraisals. The idea was conceived in the early days of the IES panel on quality in lighting, set up in 1963. Its birth was not formally announced but it was certainly a lusty infant that burst onto the lighting scene in March 1965 with a significant paper by Hewitt, Bridgers and Simons and a conference on the subject arranged by the panel at Nottingham University. Similar appraisal exercises to those at Nottingham broke out at many IES centres as well as at the summer meeting of 1966. The presentation of a paper at the 1969 meeting in Washington of the Commission Internationale de l'Eclairage (CIE) excited international interest and eventually some international activity.

A subject involved in interior lighting appraisals during this period would find himself entering a room armed with a formidable questionnaire. He would have to indicate what struck him immediately as significantly good or bad about the room and rate his general impression of the interior on a six-point scale of satisfaction. After recording information about the provision of daylight in the room, he would have to rate various aspects of the interior concerned with decoration, furnishing and layout.

Only then would his attention be drawn specifically to the lighting, and he would be asked for his impression of its suitability for the particular visual tasks needed to be done in that room. He would then have to express his satisfaction, on a five-or six-point scale, with a number of factors intimately connected with the lighting—glare and sparkle, shadow and modelling, colour rendering and brightness distribution. The suitability and the arrangement of luminaires (but not directly their appearance) would have to be assessed and the observer's last task would be to rate his final overall impression of the room, attempting to explain why it was different from the first impression, if this were the case.

Such exercises were, and still are of great educational benefit to the appraisers—drawing a line around the look sharpens critical faculties. For the appraiser who contributes professionally to the interior environment this sharpening should result in his future contributions being better, particularly if the interior he appraises is one that he himself designed. Anecdotal evidence from lighting engineers who have been subjected to this traumatic experience certainly confirms the prediction.

Effect on design criteria

But what contributions have these appraisals been able to make to design criteria for interior lighting? The honest answer to this is as yet very little. Some lighting parameters have been shown to be more significant than others in affecting the overall satisfaction provided by an interior. Where physical measurements have been made and examined against subjective assessments, grounds have

been provided for suspecting certain lighting criteria and for giving increased confidence in others, but published findings have been expressed very tentatively. Until recently emphasis has been placed on the educational side of interior appraisals and physical measurements have often been rudimentary. This situation is changing and despite the complexity of relevant parameters in interior lighting there is no reason to believe that the art will fail eventually to produce the goods which are beginning to appear in the field of streetlighting.
The most notable innovation of the last year has been the incorporation into an IES lighting appraisal at Enfield of the semantic differential technique. An observer is asked to rate his visual impression of an interior by locating the interior on a seven-point scale in each of 20 different continua, ugly to beautiful, friendly to unfriendly, warm to cool, complex to simple, etc. The aggregated results of such an exercise provide a 'character profile' of the interior, e.g. beautiful, very friendly, neutral in warmth, rather complex, etc. Appraisals with this new tool, carried out in interiors with alternative lighting systems, could provide a catalogue of information on the way different lighting parameters affect the character of an environment.
Full-blooded appraisals require considerable effort: extensive physical measurement, the processing of a large volume of data, and the marshalling of people at awkward times and places. Portable field photometry with tape output and the use of digital computers can reduce effort in the first two of these; bringing the mountain to Mohamet is currently under consideration for the third. If the appraisals of slides or photographs of an interior were to correlate with the results obtained in the actual interior how much easier would appraisal work become. Whether this correlation exists will doubtless depend on the appraisal questions and on the photographic technique, but preliminary efforts with slides and simple questions are looking promising.

Efforts converging

Designers with good taste are producing attractive luminaires for our interior and exterior environment. Lamp and fitting technologies are giving us light with increasing efficiency to be distributed as we please. Subjective lighting research seeks to define what pleases: the twin efforts of laboratory and field studies and, not least, the gentle art of appraisal are converging to find out what we like.

football floodlighting for colour TV

by R C Aldworth *and* E J G Beeson

In this country the only formal specification of outside broadcast television lighting for football pitches is a document issued by the BBC. This is based largely on American practice modified to allow for the higher sensitivity of the cameras used in Britain and it is concerned purely with the lighting of a stadium to obtain good quality pictures. If this were the sole criterion, stadium lighting would be easy, but the lighting engineer who designs a practical installation for a football club must consider the visual comfort of players and spectators as well as the requirements of the television camera—and these may be mutually opposed. The final solution may well be a compromise between these requirements, still further complicated by the site limitations that exist on most football grounds and by financial considerations.

The most common type of installation for major grounds uses four towers positioned at the corners of the pitch; a few of the larger grounds use six. A typical installation with four 30—45m towers with a load of 250kW provides a horizontal illumination of 200 lux. Although adequate for black and white television this value is well below the colour camera requirements.

Side lighting as an alternative to corner tower installation was not successful in the early days of pitch floodlighting owing to the excessive glare inflicted on players and spectators alike. It was also difficult to achieve acceptable uniformity of illumination using symmetrical projectors, but this problem was overcome when tungsten-halogen lamps and fittings became available. The lower initial and running costs of the equipment were particularly attractive to smaller clubs and, although glare is still a problem, this type of system is now common. A typical installation uses eight 20m towers providing a horizontal illumination of around 100 lux for an installed load of 100kW.

The value of illumination required to obtain colour television pictures is dependent on a number of factors all of which are linked with picture quality. With the cameras currently in use in this country and on the continent it is generally accepted that an average value of 1 500 lux measured normal to the camera is entirely satisfactory. This illumination allows the full use of zoom lenses at a shutter aperture of F4 which give acceptable depth of focus and freedom from such effects as 'lag' while allowing a margin for absorption losses in bad weather conditions.

There is some controversy as to what illumination represents the lowest acceptable picture quality. The BBC specification sets this limit at 800 lux towards the camera. German authorities have suggested 500 lux but values as low as 250 lux can be used if substantial degradation in the picture quality is accepted. Thus the range of illumination values which can provide acceptable picture quality for outside broadcasts is from 250 to 2 000 lux. At 250 lux

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only wide-angle lenses at maximum apertures can be used; 500-1 000 lux allows restricted use of telephoto lenses at aperture settings which give restricted depth of field; and 1 000-2 000 lux permits the use of the full range of lenses.

It is at this stage that the lighting engineer obtains an indication of the magnitude of the increase in illumination that must be obtained from existing installations if games are to be televised in colour.

Measuring illumination

In the past illumination values have been taken in the horizontal plane, although it was realised that the players were revealed by the illumination in the vertical plane; but television requires an unfamiliar plane of measurement. A plane normal to the axis of the camera lens varies with the tilt and pan of the camera. In a fairly typical situation the camera tilt will vary from 9° to 40° between the far and near touchlines. The specification is usually simplified by standardising on an average angle of 15° from the vertical. The illumination in this plane is usually referred to as E15 degrees. Since the proportion of horizontal to vertical illumination is dependent on the position of the light source, there is an important difference between side lighting and corner tower installations. With side lighting the average value of E15 is approximately equal to the average horizontal illumination whereas with corner tower systems the average value of E15 is approximately half the average value of the horizontal figure.

High tower or side lighting

A typical existing corner tower installation provides an E15 of approximately 100 lux with a horizontal illumination of 200 lux which must be increased up to 14 times to meet the maximum requirement. If a side-lighting installation is substituted the increases are halved and as side-lighting fittings have a higher LOR than the narrow angle projectors that must be used on corner towers, the side-lighting system has apparent economic advantages. However, the majority of the large clubs already own high towers which they are reluctant to scrap, and side-lighting can also present formidable installation problems. If glare is to be kept to an acceptable level and lens flare at the main camera position is to be controlled, mounting heights of at least 60ft (18m) must be used. Most existing stand roofs are lower than this and may not be structurally capable of supporting additional floodlights. Even when it is practicable to consider reinforcing stand roofs, the cost of additional cat-walks for maintenance and re-routing feeder cables often outweighs the saving achieved by the lower cost of floodlighting equipment and reduced electrical load.

Many clubs are involved in development schemes and if new stands are being constructed and floodlighting is considered at the design stage the problems are reduced. Few clubs construct two new stands on opposite sides of the ground at one time and the changeover between the existing and new installation can be very complicated, so there are practical and economic reasons which make tower systems worthy of consideration. A common tower headframe structure used at many clubs will support 36 1 500W tungsten projector floodlights which represents a total windage area of just over 100ft^2 (about 10m^2). This must not be exceeded although 14 times more light flux must be provided without a proportional increase in the electrical load. Part of the required increase could be achieved by using modern discharge lamps with high efficacies but these introduce light control problems due to the size of the arc tube, which will produce a more divergent beam for a given reflector diameter than the equivalent wattage tungsten filament lamp.

There is little point in packing four to five times more light into this type of beam width as very little of it would arrive on the pitch on the long distance throws involved. The spill light would also add to spectator glare which must be avoided.

So we need a lamp with an efficacy four to five times greater than tungsten in fittings giving similar beam control to existing tungsten projectors, with a maximum windage area of $0.8ft^2$ ($0.08m^2$) (or a 12in [300mm] diameter reflector) for each 1 000 lamp watts. Compare this with the $2ft^2$ ($0.2m^2$) per 1 000 lamp watts of a 1 500 tungsten lamp in a 2ft (600mm) diameter reflector and it can be seen that the new requirements are extremely onerous.

Side lighting must not be forgotten, particularly in view of the efficient way in which it can produce E15 illumination, but almost equally important considerations of windage and weight apply. In this case fittings may be mounted either on low towers or more likely on stand roofs, and the intensity of distribution must be fan-shaped to give high utilisation and good uniformity of illumination. To control glare and lens flare there must be fast run back above the peak of the beam and light must be available at low angles below the peak to illuminate the near touchline.

Light sources

In recent years metal halides have been added to the discharge tube of mercury lamps, improving both the colour rendition and lumen output. Since this colour improvement occurs in the arc itself without the use of a fluorescent coated outer jacket, much better optical utilisation and light control is possible compared with standard MBF lamps.

The source brightness of these lamps is related to the length of the arc: the long, linear sources having a brightness of 1 000 to 3 000 stilb, while the very compact sources have far higher brightnesses and efficacies of the order of 90 lm/W. The more conventional floodlights employ a jacketed tube, and are similar in appearance to the earlier mercury lamps; but recently lamps with bare quartz arc-tubes have been developed of which the linear and compact source metal-halide discharge lamps are typical. The reduced physical dimensions of these lamps not only allow for very accurate light control but also for the use of a much smaller fitting. The lamps selected for stadium lighting are a compact source and a linear metal-halide lamp.

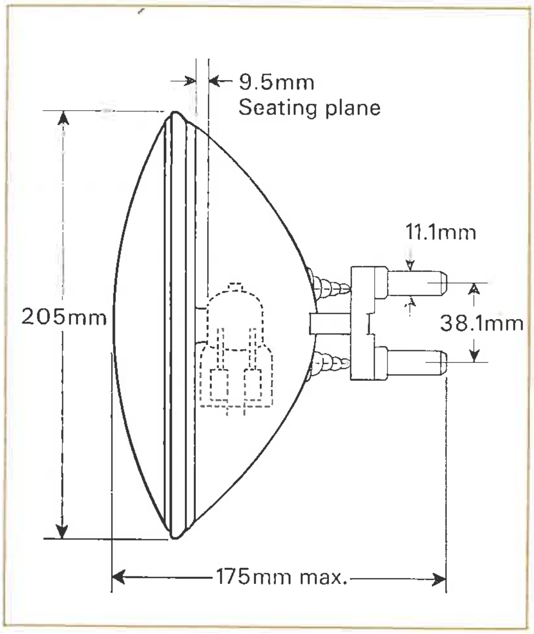
Compact source iodide sealed beam lamp and luminaire

A 1kW CSI lamp has been developed from the 400W type and is already in use in follow-spots for television studios and similar locations. The life of this lamp is 200 hours and is limited by oxidisation of the lead-in foils. When used in some optical systems keeping the seal temperature down to 350-400°C presents a problem.

However, by enclosing the arc-tube in a sealed-beam outer glass with an inert gas filling, seal failure is prevented so that lives of 500 hours are comfortably achieved, and there is no deterioration of the aluminised reflector. The high quality of the reflector optic and accurate pre-focusing results in a beam factor of at least 0.4 with a narrow well-defined beam and a minimum of light scatter.

A voltage pulse initiates the arc discharge which then operates on a series choke ballast on a 240V a.c. supply. On ignition, the blue mercury discharge is first seen, but within 30 seconds the metal-halide additives have evaporated from the wall into the arc stream and a stable white arc is established. Apart from this fast run-up time, the lamp will restrike only 7-8 min after extinction. Conventional discharge lamps often require 30 min to cool down before they will restrike.

Compact-source sealed beam CSI lamp and fitting of the type used at West Ham. The starter coil is housed directly behind the lamp chamber in each floodlight assembly.



The CSI lamp is sealed in a pressed glass parabolic reflector to give a concentrated beam.

The use of a CSI lamp in a sealed beam envelope is truly a British development, and a special luminaire has been designed for the tower installations. Lamps are mounted singly or in sets of two, three or four on a special head bracket giving paralleled beams. The assembly can be adjusted in azimuth and elevation and locked in position. The back assembly can be removed for lamp replacement by releasing toggle clamps.

The beam intensity with a clear glass front is 1.5 million candelas with a beam width of 18° at one-tenth peak. Lenses can be used to obtain a wider beam. The starter unit is mounted on the rear of the lamp unit, and lamp ballasts placed where convenient.

Linear source (MBIL/H) and luminaire

A floodlight giving a wide horizontal and narrow vertical beam spread is suitable for side-lighting installations. A 1 600W metal-halide lamp with an output of 90 000 lumens has been developed and is of almost identical size to the 1 500W tungsten-halogen lamp with an output of 33 000 lumens previously successfully used for this purpose. Unfortunately the same fitting cannot be used as it tends to run hot, so a new luminaire has had to be designed. The lamp is ballasted by a high reactance transformer having an open circuit voltage of 1 100V, making the lamp self-starting. The transformer is in a weatherproof cylindrical can suitable for all outdoor installations. A single transformer is used for the 750W linear lamp and two units in parallel for the 1 600W lamp.

The pencil-slim 1 600W lamp operates in free air allowing the design of a compact and lightweight fitting with excellent optical properties. The luminaire has an asymmetric anodised specular optic supported by end castings which also support the lamp within the luminaire. It is enclosed by a toughened glass front and within is a polished and anodised reflector-bar to eliminate spill light and give a sharp run back of the beam profile. The peak beam intensity given is just over 250 000 candelas.

If the arc discharge is examined closely it will be found that a colour difference occurs across its diameter. This is overcome by lightly frosting the arc-tube. A well balanced and good colour beam is projected by the luminaire.

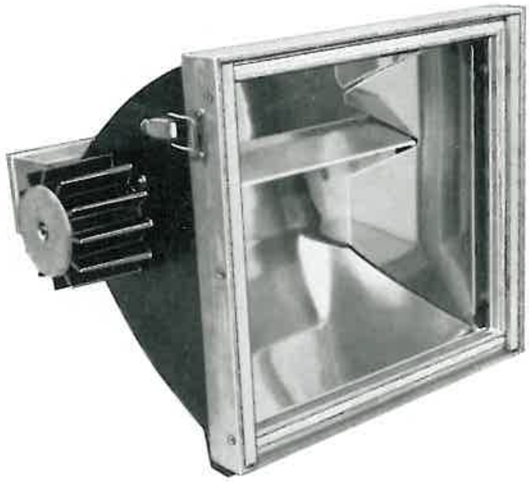
Two new installations

At the start of the current football season two installations were completed using the two new light sources designed to meet the widely different requirements of tower and side-lighting installations described above. These are at West Ham United, using 1 000W CSI lamps on corner towers, and at Arsenal, using 1 600W linear metal-halide lamps in a side-lighting system.

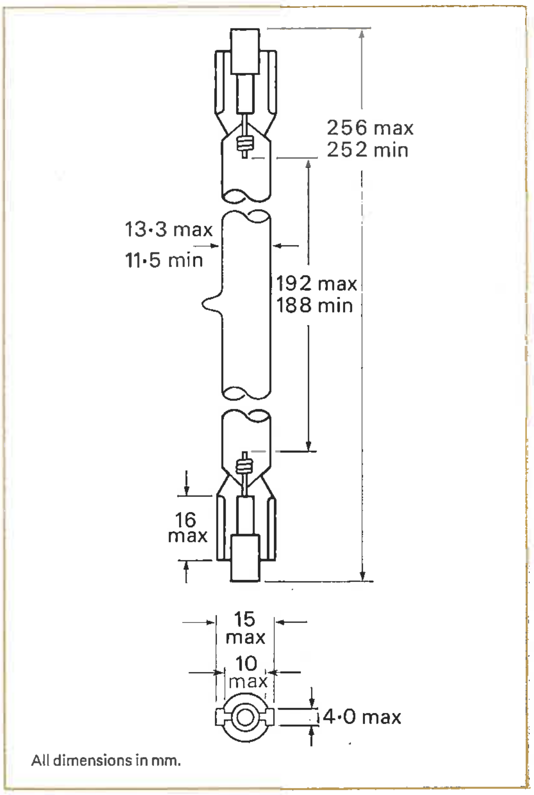
West Ham

From experience of earlier four-tower installations it is generally accepted that the best siting for corner towers is five degrees back from the centre of the touchline and 15 degrees back from the goal mouth. Even with this arrangement it is difficult to achieve high values of E15 on the near touchline and at West Ham the towers are actually in line with it. Supplementary side-lighting under the cantilevered roof of the new stand, which includes the camera gantry, was considered but the cost of reinforcing the structure and the need to provide access for maintenance proved prohibitive.

There are also problems in ensuring visual comfort to the spectators as the closest fan stands only a few feet from the touchline with his eyes almost at pitch level. Under these circumstances it is impossible



1 600W MBIL/H lamps are mounted in this specially designed fitting for side-lighting installation. The horizontally mounted lamps allow very tight beam control.



The pencil-slim 1 600W MBIL/H lamp.

Opposite: at West Ham's ground at Upton Park the floodlighting towers, carrying a total of 324 lamps, are in line with the touchline. In most other installations they are set further back, simplifying the lighting problems.

Right: the excellent illumination of players both for spectators and TV cameras at Arsenal's Highbury ground.

Below: Arsenal's side-mounted floodlights using 100 of the new Atlas MBIL/H lamps give seven times more light than the previous installation.

to meet the full requirements of the lighting specification if the spectators are to see with reasonable comfort. The success of the final compromise is an indication of the excellent light control achieved by the sealed beam lamp.

To achieve the illumination 81 1kW lamps were required on each tower. As it is unnecessary to aim this number individually to cover the pitch, the lamps were mounted in groups of three in 27 3kW units on the existing headframes. The control gear was mounted in a single housing at the base of each tower.

This installation gives an increase of eight times the original illumination value for only a 50 per cent increase in electrical load, the total load being 400kW. To provide this additional capacity an extra feeder cable was brought to each tower operating one-third of the lamps. In view of this natural division of the supply it was decided to switch the lamps in each group so that one-third, two-thirds and full illumination could be provided with similar uniformity and running economies made when floodlit matches are not televised.

The final installation provides an average horizontal illumination of 1 600 lux and an average E15 value of 860 lux. The diversity of E15 is within the limits of 150 lux within any three metres and the average illumination on the near spectators is 300 lux. The installation therefore complies in all respects with the lower range of the published specification.

Arsenal

Arsenal, unlike other leading clubs, has always favoured side-lighting systems as it has two identical stands with the leading edge of the roof nearly 60ft (18m) above the pitch. Up to now the club has had to accept excessive glare and television cameras have been seriously hampered by lens flare. The use of the linear 1 600W lamp and fitting has greatly improved this situation.

Providing adequate illumination on the near touchline still poses a problem. Fortunately the roof of the east stand, which accommodates the television camera gantry, is set back 60° from the near touchline, which is just acceptable.

Lighting the far touchline introduces the now familiar problem of providing illumination towards the camera without excessive glare to the spectator. As at West Ham the Arsenal's nearest spectators are only a few feet from the touchline with their eyes inches above the pitch. The fast run-back above peak achieved by the reflector baffle combination has reduced glare to reasonable limits.

Arsenal's requirements were simple: the club asked for the maximum possible illumination on the pitch, which it hoped would meet television requirements, but this had to be achieved without increasing the existing electrical load.

Using a hundred 1 600W fittings an average E15 value of 880 lux was achieved The average horizontal illumination is also 880 lux. This installation fully complies with the specified illumination requirements both for the pitch and the front spectators. The total load of 220kW is just over half that at West Ham.

Although the demand for increased illumination came originally from the television companies it would be wrong to think that they alone benefitted from it. At both the grounds described, the spectators' view of the game has been greatly improved. However, this will only remain true if the same care to achieve glare control is taken in future installations. Higher illumination does not necessarily produce glare but this is bound to happen if the sole preoccupation is with efficacy of the light source without consideration of other factors.

'what colour is it?'

by K Scott *and* E J G Beeson

"What colour is it?" is a question which is relevant to almost every visual aspect of the human environment. It is a simple request for information but the process by which we appreciate colour is complex. The object illuminated by a lamp will not, unless it is white or grey, reflect all colours equally well and the light received by the eye depends not only on the spectral power distribution of the lamp but the spectral reflectivity distribution of the object it lights. The eye itself does not respond equally well to all wavelengths but is more sensitive to those in the middle part of the spectrum and less to the red and blue light at the ends; so there is a third selector in the colour sensation change, the spectral response of the human eye. It is a complex process, but clearly one which is dependent on the spectral composition of the source of light. To achieve good colour rendering of all objects the light source should emit as nearly as possible all visible wavelengths at approximately equal energy and perhaps also some invisible wavelengths to excite fluorescent whiteners and dyes.

Sunlight and the xenon lamp

Our natural source of light, the sun, has a spectral power distribution of this type: the shape of the curve varies widely with time of day and atmospheric condition but it is always continuous throughout the visible spectrum indicating the emission of light of all wavelengths. Figure 1 curve A shows the spectral power distribution of a combination of noon sunlight and sky light; curve B is the spectral power distribution of a xenon discharge lamp. This matches the curve for the natural radiation very well—in fact, it provides probably the best colour rendering of all artificial light sources.

Xenon lamps are available in ratings of 250W-20kW in compact source types and from 1-20kW in linear forms, operating with efficacies of 25-50 lm/W depending on loading. These lamps are widely used in the cinema for film projection, as a source for solar simulators, fadeometers, and occasionally for lighting large areas such as city centres and sports stadiums. Because they take a high current, require a high voltage for arc ignition and are rather costly, they are not used for more general lighting applications.

The ordinary domestic lamp emits continuous radiation with acceptable colour rendering but most of the light is concentrated at the red end of the spectrum giving a generally warm appearance to objects seen in its light. Despite its generally accepted colour and convenience the incandescent lamp has the disadvantage of low luminous efficacy of about 12-25 lm/W.

The uncorrected high pressure mercury vapour lamp is little used to-day since its line spectrum, which is particularly strong in the blue/green and devoid of red light, gives poor colour quality although efficacies of 50 lm/W are achieved. The spectrum of the low pressure sodium lamp is another example of a restricted visible radiation. The light emission is confined to a sodium doublet giving monochromatic yellow light with even poorer colour rendition qualities than mercury, but efficacies of at least 185 lm/W can be achieved. It is this lumen performance which offers the most attractive economics for

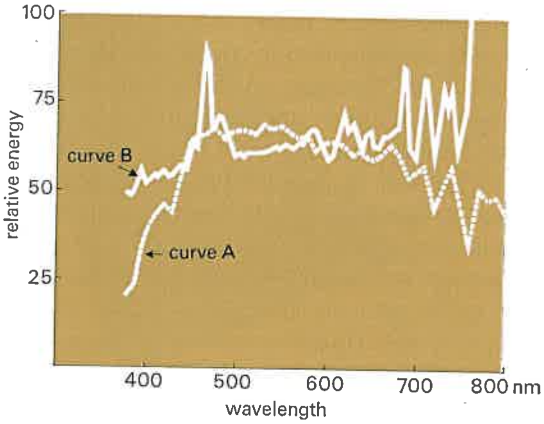


Figure 1 Spectral energy curves for natural daylight and Xenon arc.

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motorway and street lighting and low pressure sodium lamps are almost exclusively used for this purpose.
The very high efficacies of low pressure sodium lamps are closely related to the response of the eye to coloured light. As stated above, the human eye is most sensitive to light in the middle of the spectrum; consequently if all the energy can be used to emit light in the middle parts of the spectrum a much higher efficacy in lumens per watt will result. Conversely, if the energy is more widely distributed throughout the spectrum to achieve good colour rendering, the luminous efficacy is reduced. For example, the recently introduced high pressure sodium lamp provides a marked improvement in the colour rendition quality but with a lowering in its efficacy to about 100 lm/W. In Figure 2 the spectral distribution shows how the sodium doublet lines are absorbed with broadening of the spectrum taking place on each side, extending into the red and towards the green. Colour rendition is much improved in the yellow-white part of the spectrum but it is deficient in any blue light. The appearance is now a warm yellow compared with the predominant yellow of the low pressure sodium lamp. These lamps are being used for city centre lighting where colour becomes a more important aspect of the environment, for floodlighting and for some interior lighting applications where high luminous efficacy is more important than accurate colour rendering.
Over the past few decades progress has been made in improving the colour of high pressure mercury lamps by using phosphors, such as magnesium fluo-germanate, within the outer envelope to add red light to the mercury spectrum. Today the deep red of the earlier phosphor has been superseded by yttrium vanadate phosphor emitting an orange red as seen in Figure 3. Not only does the phosphor radiation provide enhanced colour quality within the eye visibility range but the total lumens are increased to give efficacies nearer 60 lm/W. These lamps, known as °Kolorlux, not only fulfil the traditional tasks of mercury lamps in exterior and industrial lighting but are useful in many commercial interiors.
Another way to improve the colour quality of the mercury lamp has been to combine it with the radiation from a tungsten filament, the latter also acting as the arc tube ballast so that no control gear is required. Although the overall luminous efficacy is reduced to about 22 lm/W, lamp life approaches 6 000 hours. Some lamp designs also embody the yttrium vanadate phosphor coated bulb to give very acceptable colour quality. The initial embodiment cost is low and with this type of lamp an existing tungsten lamp installation can have its lighting level uplifted by 50% simply by changing a lamp.

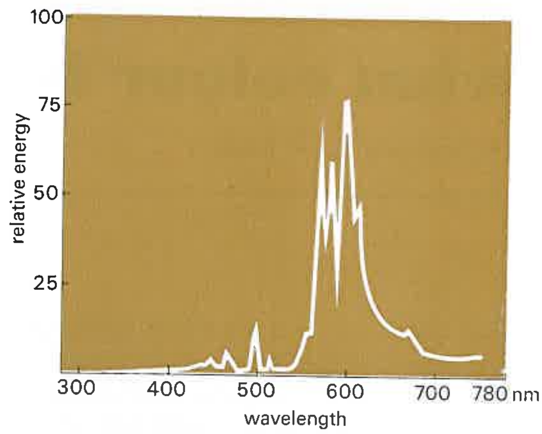

Figure 2 High pressure sodium lamp (SON)

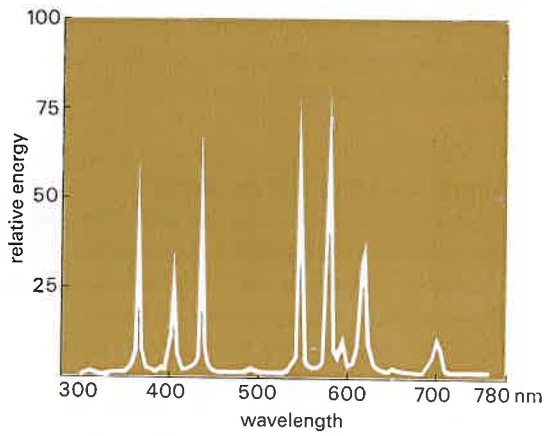

Figure 3 °Kolorlux lamp (MBF)

Introduction of metal halides

More recently the introduction of metal halides has opened up a new frontier in the quest for good colour discharge sources in a more compact form than the fluorescent tube. The arc tube is similar to a mercury lamp but other metals added in the form of halides are excited by the high temperature discharge and emit their characteristic spectral colours. Metals not widely known, such as scandium, dysprosium gallium and thallium, are used in mixtures with more common metals to provide a much more complete spectrum. Typical of these lamps is the °Kolorarc, the spectrum of which is shown in Figure 4, where a much improved colour balance is achieved over the visible region. This can only result in improved colour rendition and for the first time we have lamps with efficacies of over 80 lm/W which are finding applications for the lighting of stores, supermarkets, shop windows, offices, etc. They provide a new approach for the lighting engineer since highlights can be provided in large area lighting to

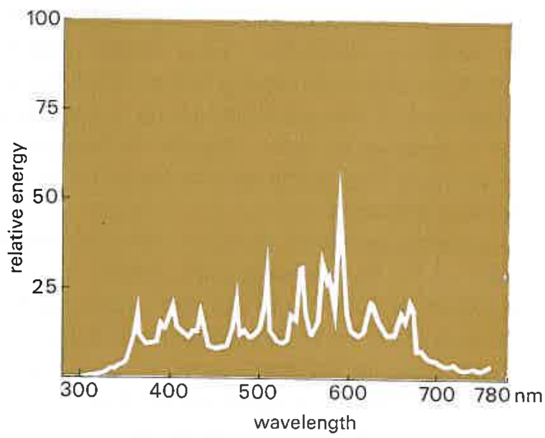

Figure 4 °Kolorarc mercury halide lamp (MBIF)

give modelling effects and make the environment more interesting. By increasing the vapour pressure and loading in metal-halide compact source lamps the line spectrum is broadened to give a substantial increase in the continuum with excellent colour rendition (Figure 5) and efficacies of over 90 lm/W. Small in physical size, the lamps are used for special lighting effects such as in follow spots for theatres, television studios and projection. A 1kW lamp contained in a sealed-beam form is used in football stadiums to meet the high lighting levels needed for colour television.

The colour characteristics of light sources are basically defined by their spectral power distribution, and it is necessary to have this information to decide how the colour of objects will be rendered. It is often convenient to know the colour appearance of the light emitted. This characteristic is known as its chromaticity and can be calculated from the spectral power distribution data. Figure 6 is a chromaticity diagram showing the relative positions of the lamps described. Increasing values of x indicate a more red appearance, increasing values of y a more green appearance; as x and y both decrease the colour becomes more blue. The white line indicates the way in which the chromaticity of a full radiator varies with absolute temperature. The position on this curve of an incandescent tungsten filament lamp operating at 2 800°K is illustrated.

When incandescent lamps are used in colour television studios the essential criterion for colour balancing a camera is to hold the colour temperature of the lamp at about 3 100°K with a tolerance of ±300°K. This is comparatively simple to achieve since the chromaticity of a tungsten filament lies on the full radiator locus, but most of the discharge sources do not lie on this line and it can be misleading to attempt to quote precise colour temperature for them. Their apparent colour temperature spreads from about 3 000°K up to 6 000°K. Those above the full radiator locus will have a bias towards the green with a high efficacy, while those that fall below it, such as the CSI lamp, have a warmer colour appearance.

It is perhaps necessary to emphasize that the colour appearance of a discharge or fluorescent light source may resemble that of an incandescent source but that its colour rendition may be quite different. The eye is, in fact, incapable of distinguishing between a monochromatic colour and one which is the result of mixing two or more wavelengths. This can be demonstrated by comparing the appearance of a coloured sample in the near-monochromatic yellow light of a sodium lamp and in the light from an apparently matching yellow source obtained by using selective filters over an incandescent lamp. Greens and reds which are clearly visible under the latter source will appear as shades of brown under the monochromatic source. In other words, although the *colour appearance* of the two sources is similar their *colour rendering* properties are quite different. It can consequently be very misleading to classify light sources having line spectra by their apparent colour appearance and for this reason it is now usual to publish spectral distribution data as well as specifying the chromaticity co-ordinates of discharge sources.

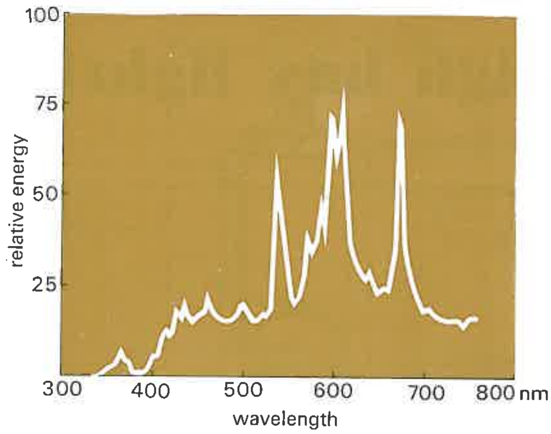

Figure 5 Compact-source mercury iodide lamp (CSI).

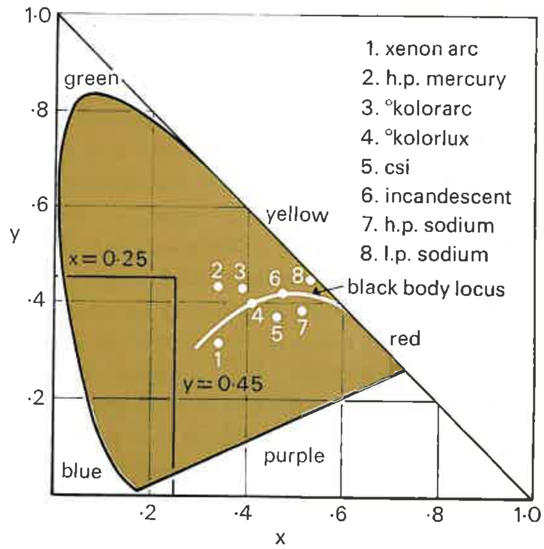

Figure 6 Chromaticity curve, showing black body locus.

Conclusions

Light has proved essential to progress and man-made light is increasingly important in our increasingly man-made world. If the lamp is to be not only a utility but also a means of enhancing our environment, it needs to render colours well. We are accustomed to the visual effects of natural lighting, of incandescent lighting and also of fluorescent tube lighting. The present achievement in discharge lamps allows further versatility in the design of lighting both for exterior and interior environments.

high bay lighting

by D Wilkinson

Introduction

Until the introduction of high wattage discharge lamps of good colour rendering and appearance, high bay lighting, as the name suggests, was used almost exclusively in factory buildings with truss heights of 40ft (12m) or more. Such factories are generally engaged in heavy engineering and the nature of the work is dirty so that maintenance presents a problem. By mounting the fittings high, the amount of dirt which reaches them is reduced and, more important, room is available for large pieces of machinery such as travelling cranes.

New lamp types, which produce far better results than were practical previously, are now on the market and as a result high bay fittings are found in locations which are anything but high or dirty. These new lamps are the MBF/U °Kolorlux, MBFR/U reflector °Kolorlux, MBIF °Kolorarc, MBI/L Metalarc and SON high pressure sodium and they present a number of advantages:

Temperature Minimum starting temperature is −30°C on a supply voltage 85% of nominal (i.e. 200V on 240V nominal). This ensures trouble-free operation under external canopies and in areas close to open doors, such as garage workshops and warehouse loading bays.

Resistance to vibration With the exception of high pressure discharge lamps, every source used for general lighting in industry employs a filament. The low voltage cathodes in fluorescent tubes are far superior to tungsten lamp filaments in resisting stresses imposed by vibration, but the solid form of the electrodes of high pressure discharge lamps results in the most robust construction of any general purpose lamp type. This asset can be used to its fullest advantage in plants where extreme vibration from cranes and machinery is encountered. Because the cathodes are so massive, they resist damage by electron bombardment from the heavy arc current and lamp lives well in excess of the quoted average are obtained, particularly when switching frequency is low. It is good lighting practice to replace the lamps at 7 500 hours to retain the calculated illumination values, but long life can be useful in locations where maintenance is extremely difficult.

Compact light source of high brightness Careful design of fittings is essential if disability glare is to be avoided. The concentrated distribution needed for this results in a high utilance, so that fewer lighting points are required, with obvious advantages in installation and maintenance costs. In addition, such concentrated light sources simplify viewing of small objects by intensifying modelling. This is very important in the textile and man-made fibre industries where it is necessary to examine production involving small diameter threads with great speed and accuracy. Very high illumination levels can be

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obtained when fittings are mounted at low level. A glance at the IES Code shows many requirements for *minimum* illumination values of 900, 1 300 or 2 000 lux and fittings using discharge lamps can readily achieve these readings. Illumination requirements are continually increasing and this use of high bay fittings is bound to show a dramatic acceleration. Previously published minimum mounting heights of 30 to 60ft (9 to 18m) for high wattage fittings were based on generally accepted techniques when illumination levels were relatively low. Experience has shown that extremely comfortable and pleasant conditions can be provided, along with an illumination well in excess of 1 000 lux, when 1 000W reflector °Kolorlux lamps are operated at mounting heights of around 16ft (5m) above floor level.

Problems associated with high bay lighting

The problems of operating high pressure discharge lamps have been much exaggerated. There are three difficulties:

(a) The extended run-up time to full light output.

(b) The re-striking time required after switching off (or mains failure) before the lamp has cooled, and mercury vapour pressure dropped sufficiently for the arc to be re-established. This problem does not apply to SON lamps.

(c) Potential failure of mineral insulated cables used to connect lamps and gear when the gear is mounted remotely. This is due to high starting voltages breaking down the insulation.

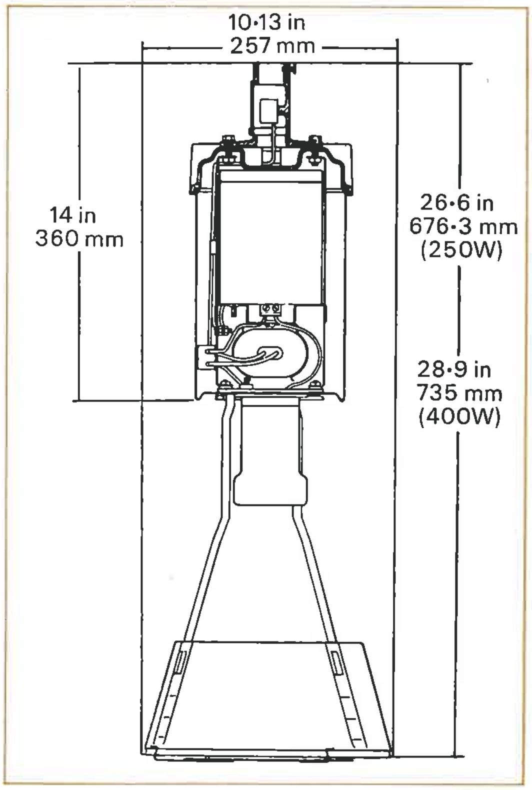
Run-up time The run-up time of five minutes to full light output does seem excessive when compared with most other light sources. However, since almost 20% of peak output occurs within two minutes of switch-on, which represents 80 lux in a 400 lux installation, the problem is less serious that at first appears.

Re-striking time At the design stage of a lighting scheme more concern is shown over this aspect than any other. But again practical experience shows that it is much exaggerated and seldom occurs in practice. Breakdowns in supply are rare in Britain and a simple emergency lighting system consisting of a small percentage of fluorescent, tungsten or tungsten-halogen fittings may be added to the installation, and will also provide a low level of lighting for night-time security purposes. The minimum service levels of illumination given in the IES Code are such that artificial lighting is essential during all working hours, so that the problem of lamps failing to strike immediately after being switched does not arise.

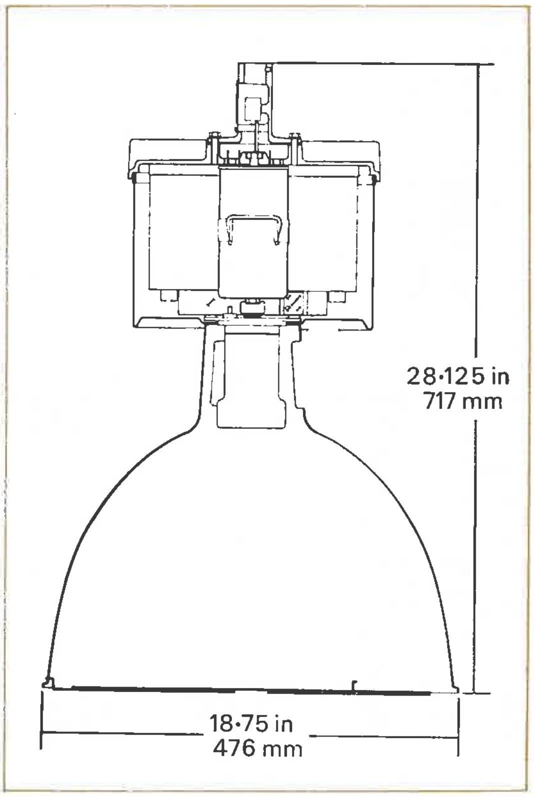
Mineral insulated cable Although mineral insulated cable is perfectly satisfactory for wiring to the control gear, any inter-connection between the gear and the lamp should be in PVC, high temperature PVC or PTFE insulated cable (depending on the operating temperature of the particular fitting) in a suitable protective enclosure.

Fitting types and control gear

There are two basic types of fitting: first, a simple reflector shield for use with the reflector °Kolorlux lamp; second, a spun aluminium BZ1 reflector for use with all non-reflector lamp types. Both are available with integral or remote-mounted control gear. At present the 1 000W MBI lamp can be operated only with remote control gear. Maximum spacing/mounting height ratios are 1·25:1 for reflector lamps and 1:1 for the BZ1 reflector. Although from external appearances not strictly high bay, a modern fitting using 80W or 125W °Kolorlux lamps is available for low ceilings. It has proved very practical in such places as printing and chemical works where large numbers of pipes and ducts make the use of fluorescent fittings difficult.



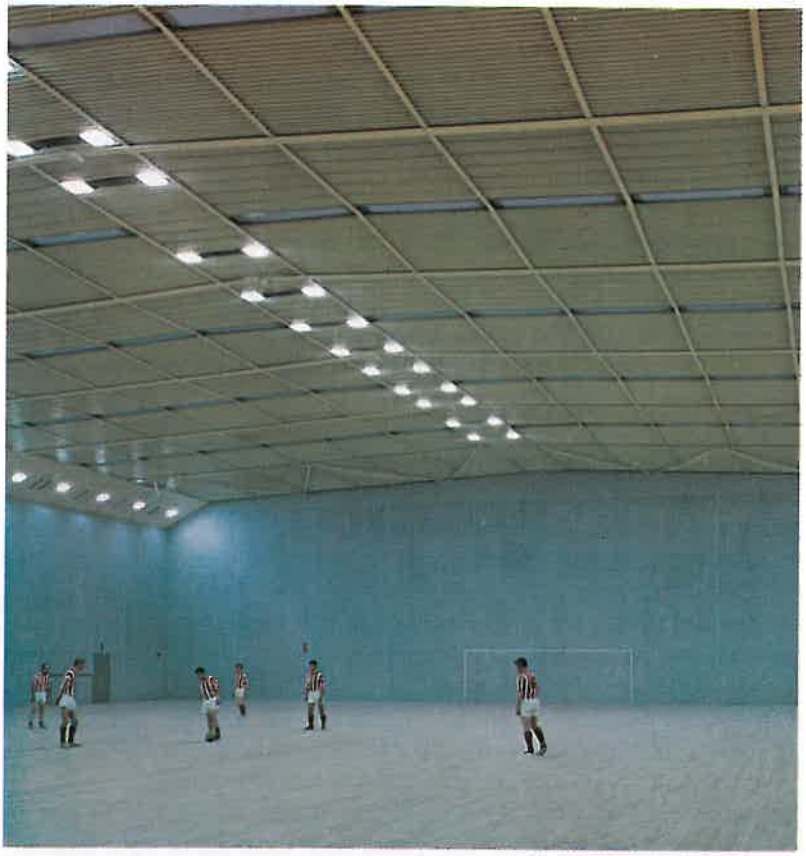
A typical high-bay fitting for 250W or 400W MBFR lamps. The reflector shield can be used alone or with a control-gear box as shown.



A deep spun aluminium reflector giving BZ1 glare rating, used with a 400W MBIF lamp. Control gear can be mounted above the reflector, or installed separately.

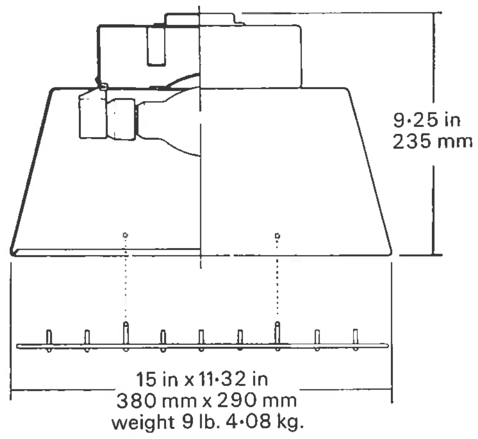
Atlas °Kolorlux and °Kolorarc lamps in sport and industry.

Alongside: 400W °Kolorarc lamps in OAC area floodlights recessed in the ceiling provide an illumination of 500 lux at Sunderland Football Club's new training gymnasium.



Below: Herbert Ingersoll's precision tool plant at Daventry (Northants) is a single-storey windowless building covering 102 000 ft² (approximately 12 000m²). It is lit entirely by 450 fully recessed Mazda high-bay lighting units using 1 000W °Kolorlux lamps.

Many types of exterior floodlighting fittings may be successfully employed where they meet particular requirements of light control or fitting design and there is a growing range of special fittings for these applications.
Precision wound ballasts are used for many discharge lamp circuits in both high bay fittings and remote mounted gear. The small, accurately wound coil coated with epoxy resin and wound without interleaving paper insulation has much improved heat distribution characteristics resulting in increased life and a five-year guarantee for the ballast.
Where rotating plant is in use adjacent rows of fittings should be connected to different phases. This arrangement is normally used by the electrical designer when balancing high wattage load and is therefore easily achieved.



A ceiling-mounted industrial fitting for a 125W° Kolorlux lamp. The control gear is housed in the box above the reflector.

Applications

The uses of high bay fittings are so many and varied that it is easier to list those in which they should be avoided. They can, in fact, be used almost anywhere except in places where a diffused light is required, as for example in plant rooms or above luminous ceilings.
Uses in industry The traditional areas are assembly shops, chemical works, foundries and iron and steel works where the reflector lamp is normally employed. In all areas requiring illumination levels in excess of 600 lux, the BZ1 fitting is an economical first choice. Under canopy use is practical since the majority of fittings are drip-proof and/or rain-proof and the outer envelopes are of hard glass.
Non-industrial use Specially designed fittings can produce an attractive appearance for lighting buildings with high ceilings including shops, offices, banks and churches, and indoor sports buildings where the ceiling height is great enough to make a surface mounted fitting acceptable.
Many indoor sports are televised and, as with outdoor sports, the best light sources for providing the required colour rendering and lighting intensities for colour television are often MBI/L Metalarc and MBIF °Kolorarc.
For low ceiling heights, or where surface obstructions cannot be tolerated (either from an appearance or a playing point of view), recessed fittings with top or bottom access for lamp maintenance have been developed. This system has great potential in the lighting of swimming pools where a concentrated light source is preferable to the diffused light of fluorescent lamps to give penetration into deep water with a resulting improvement in safety. The colour rendering properties of the MBIF °Kolorarc make it especially suitable in such situations.

Future developments

Of all light sources, high pressure discharge lamps offer the best possibilities for further improvements in efficacy. The theoretical maximum for a fluorescent tube is 100 lm/W but already mercury iodide and high pressure sodium lamps are approaching this figure in an early stage in their development, and the theoretical maximum in this case is 150 lm/W for good colour rendering. In addition, efficacies of commercially available discharge lamps are increasing at a much greater percentage rate than is the case with other lamps. These potential improvements are certain to result in large scale increases in the use and applications of all types of high bay fittings.

linear sources on the motorway

by P D Gunnell

That good street lighting saves accidents is well established. Apart from other benefits, such as faster and more comfortable travel during the hours of darkness, this is the principal reason for installing highway lighting. Although motorways are designed and have proved to be safer than conventional roads, lighting can be expected to show a similar accident saving rate. On conventional roads this is in the order of 30 per cent but there is as yet insufficient data available to confirm it for motorways owing to limited experience in this country.

The allocation of Government funds for traffic route and motorway lighting is based on a cost benefit analysis of each scheme, in which the estimated cost of accidents is weighed against the operating cost of the scheme. The results of this analysis indicate the priority to be given to a particular scheme and are related to the net benefit expected to be obtained in accidents saved by the installation of lighting.

The brief for the designer of street lighting equipment is therefore to provide the most economical solution within the limits of the specification and code of practice. The British Standard Code of Practice for Trunk Roads, which governs the design of lighting equipment and installations, is confined to conventional traffic routes and makes no recommendations for motorway lighting. It is therefore necessary to build up a specification based on this code, but with amendments to cater for the particular conditions found on the motorways.

Motorway lighting specifications

The first motorway lighting installation in the United Kingdom was on six miles of the M4 between London and Heathrow in which 700 Atlas 140W linear lamps were used in Alpha 6 cut-off lanterns mounted on 12m columns on the central reserve. The design of these lanterns was based on the Code of Practice, standard A2, and they emitted 13 000 lumens in the lower hemisphere. The light colour of the concrete road surface assisted the performance of the installation, which was found quite satisfactory in practice although it was realised that a higher luminous flux would be needed for the black surfaces often found on other motorways.

To meet the requirements of a black road surface the starting point in determining the design of a new lantern was that about 40 000 lamp lumens would be needed to give 24 000 lumens in the lower hemisphere; thus it would have an LOR of 0.6. This could be achieved by two 140W linear sodium lamps in a lantern similar to that already in use, but a single 31 000 lumen 180W SOX lamp could provide approximately the same performance and show a saving in the lamp replacement cost.

Careful investigations were made and, as a result, a specification was laid down by the Department of the Environment based on BSCP. 1004. This called for lanterns to provide a light output of 20 000 lumens in the lower hemisphere and thus gave a lead for further development of linear lamps for motorway lighting.

Design of lamps and lanterns

The 140W linear lamp has a proven record of reliability on many

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140W linear sodium lamps in Alpha 6 cut-off lanterns used to light the M4 motorway to Heathrow—London Airport. The night view shows the excellent seeing conditions; by day lanterns and poles are elegant and unobtrusive.

trunk roads and on the M4 motorway, but because it did not meet the lighting design requirements described above it became necessary to improve the performance of the 200W linear lamp, and to re-design the Alpha 6 cut-off lantern used on the M4 to give a higher light output ratio. Moreover, since the specification for motorway lanterns now called for lamp, control gear and a photo-electric switching device to be incorporated in the lantern, the opportunity was taken to design a new range of lanterns for both the 140W and 200W linear lamps. This also gave the considerable advantage of standardising on one optical design since both linear lamps have the same physical dimensions.

Design requirements

The brief, therefore, was to design a series of lanterns having standard optical enclosures to meet BSCP. 1004 for traffic route lighting and DOE specification for motorway lighting. Alternative methods of construction using several different materials were examined to meet the specifications. The choice of material was very important since it had to have the following features:

1. Resistance to corrosion.
2. Temperature range to cover operation of up to two lamps and control gear in the lantern.
3. The ability to withstand solar radiation combined with heat from the operating lamp and control gear.
4. Long maintenance-free life in outdoor conditions.
5. Moulding quality to ensure sharp definition of contours for the accurate location of reflectors, gaskets and securing catches.
6. History of satisfactory operation in outdoor use with particular reference to street lantern canopies.

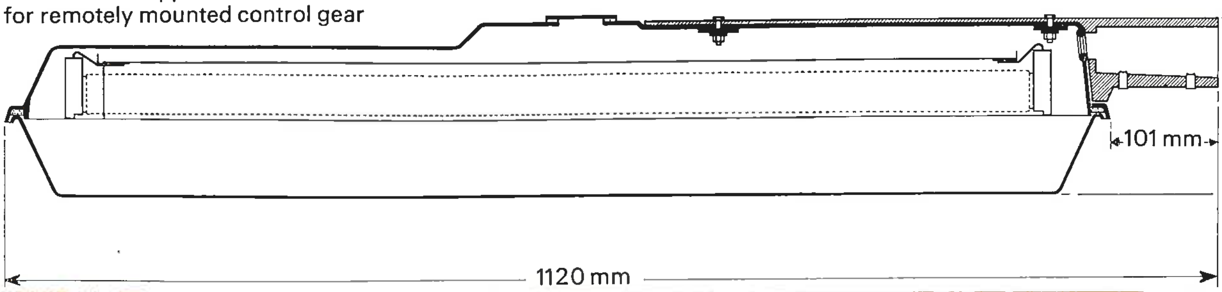
Pressed aluminium was considered but past experience indicated that when used for a lantern three feet in length there is insufficient stiffness in this construction due to the relatively light gauge of the material.

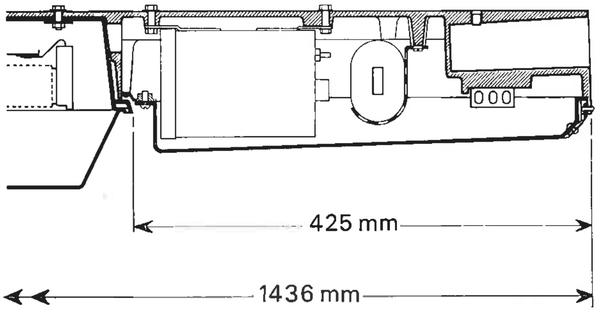
Moulded glass reinforced plastic was chosen for the lantern canopy housing the optical system, although the load-bearing end-support took the form of an aluminium casting capable of housing lamp control gear when required. This material has been widely employed on the continent over the past nine years but only limited use has been made of it in the United Kingdom.

Fothergill and Harvey, who are raw material suppliers for pressure mouldings in this country, importing the resin from Bayer, Germany, offered a suitable material which was finally chosen. The glass fibres, made by Pilkingtons, are chopped up and impregnated with resin. FLOMAT 25, the material selected, has good weathering properties and adequate strength for the canopy as designed. Further, this material is expected to give life of at least 15 years and tests showed that there was no marked depreciation of the material in outdoor use.

Additional tests carried out at Thorn Lighting's Development Laboratories confirmed that FLOMAT 25 would be more than strong enough for the service requirements of the lantern canopy. The material has the advantage of being the most satisfactory for outdoor use and has a heat distortion temperature of 150°C, allowing a generous safety margin.

The method of moulding the glass fibre material is of some interest. When it was first introduced the chopped glass fibres were laid by hand in a female mould and the polymer resin added. This method is still used in the manufacture of large complicated structures such as motor car bodies and the hulls of boats, but a much more economical method is the use of matching moulds. The impregnated fibre glass





mat is inserted between the moulds and pressed. The process is both quicker and cheaper than the manual 'lay-up' method and results in a stronger and lighter object with a smooth finish on both sides in place of the rough surface which is unavoidable on the inside of objects made by the earlier method.
Since the introduction of glass reinforced plastics, several new and improved materials have become available so that the materials now being used result in an article superior in performance to that previously possible with earlier materials and methods of moulding.

Specification

Detailed specifications for the lantern were as follows:
1. Side entry mounting for single 20 000 or 27 500 lumen lamps.
2. Side entry mounting with one 20 000 lumen lamp, control gear housed in end support casting.
3. As 2 but for one 27 500 lumen lamp.

Each type had to incorporate 'knock-outs' and terminal block facilities for photoelectric cell switching and all had to comply with BSS. 1788 cut-off for sodium lanterns.

Methods of construction

The Alpha 6 lantern range has been re-designed to minimise the use of aluminium to keep down cost and weight of the lantern. Aluminium castings are used only for those parts of the lantern which are load bearing. These carry the relatively heavy control gear where necessary and also provide a metal surface through which the heat from the latter can be dissipated.
The use of 140W and 200W linear sodium lamps of the same dimensions enables a common optical system to be employed for both traffic route and motorway specifications. This reduces tooling cost and results in a lower unit cost which is still further decreased by the fact that production in volume is possible.
A one piece canopy was considered but this type of construction would lead to three separate sets of tools to meet the alternative specifications. An unnecessarily expensive solution would be for

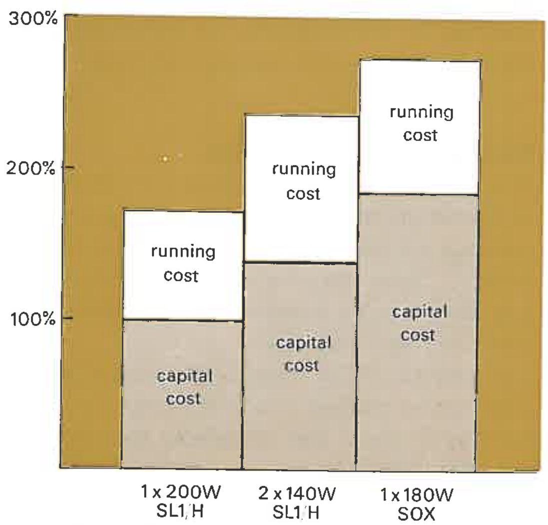
The standard lamp-housing with its glass-fibre canopy and acrylic enclosure is suitable for both 140W and 200W linear lamps. Cast aluminium support members are designed to carry control gear or not as necessary.

the gear housing in the canopy casting to remain unused where gear was not required in the lanterns. Consequently the optical system was designed as a separate entity which could be attached to three types of end support. Since the optical system is common to each design it was possible to limit tooling costs to the part of the lantern in which variation is required. Three end supports were designed, to each of which could be attached the common one piece enclosure incorporating the optical system. By this means the range of lanterns specified could be economically produced.
Since the load bearing section of the lantern also contains the lamp control gear when required, the optical enclosure can be free from load and therefore made in a lightweight material attached to the end support. The effect of this construction considerably reduced the weight of the lantern.
Gravity die cast aluminium was chosen for the end-support which attaches the lantern to the column bracket arm. Its strength and ability to dissipate heat when lamp control gear is mounted within it made it a very suitable material.

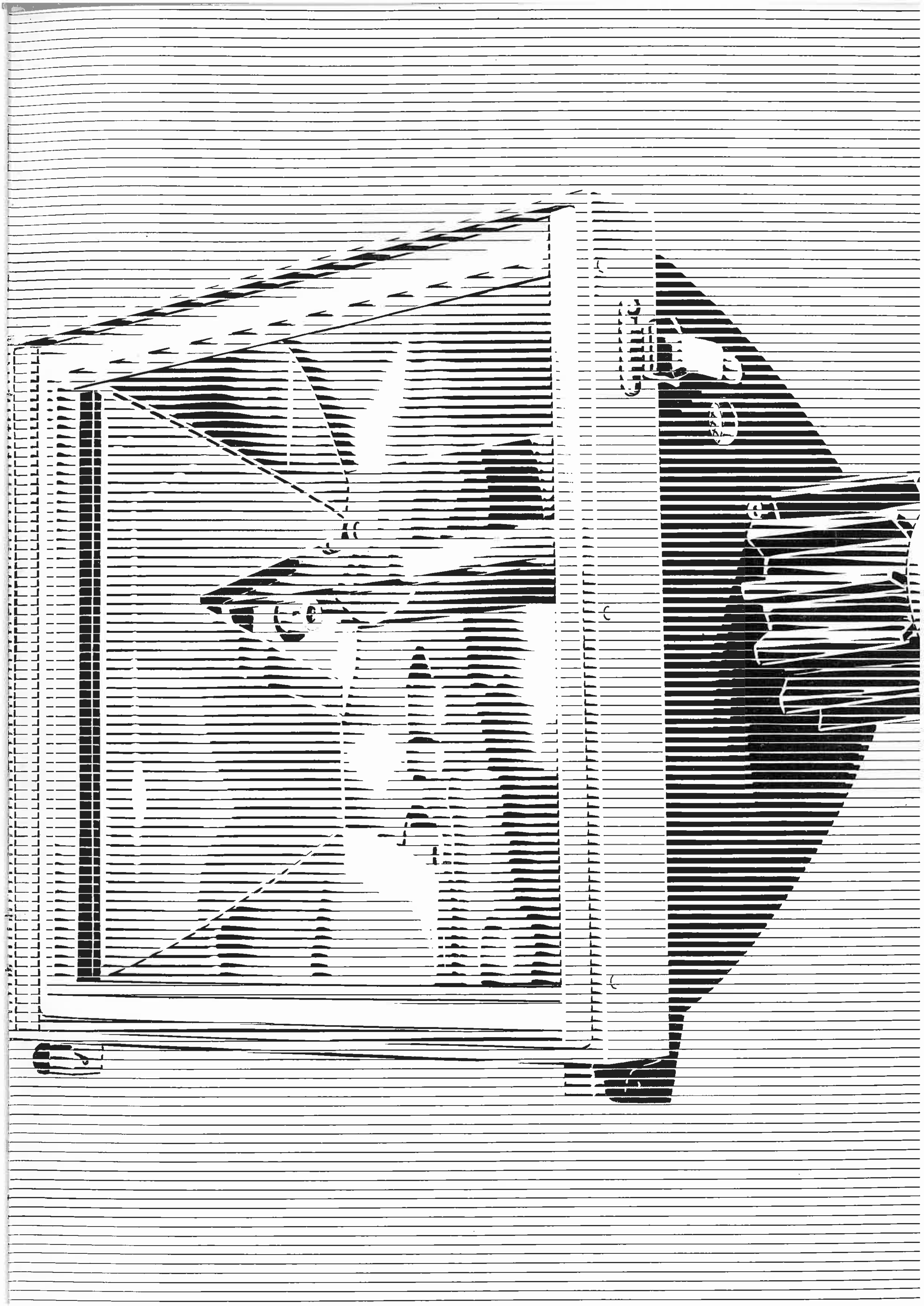
Economics

When examining the economics as shown in the cost comparison it is evident that although the 180W SOX lamp has a higher efficacy in lumens per watt and a slightly lower power consumption than the 200W linear lamp, the size of the latter allows lanterns to be relatively smaller. Columns too are lighter in weight and less costly due to the lower weight and windage of the lantern, lamp and control gear; in addition, lamp replacement costs are lower. This clearly illustrates the point that it is the combination of apparatus in association with the lamp that has a final bearing on the economics rather than consideration of lamp efficacy in isolation from the total unit.
Furthermore, motorway lighting costs are always substantially higher, initially, than lighting for populated areas because the cable is used only for supply to the installation. The average cost of supplying and laying a cable represents a high proportion of the capital involved and is the largest single item of expenditure. The low starting voltage characteristic of the 140W linear lamp allows a medium voltage of 530V so that a considerable reduction can be made in the size and cost of the cable. Since lantern costs remain the same, it can be seen that by using a small diameter cable a saving of at least 15 per cent in the capital cost can be achieved. A further reduction in control gear costs for the medium voltage scheme is possible as this now employs a series choke as distinct from the more complex high reactance transformer for a 240V supply system.

Capital cost	140W sodium linear	
	240V	530V
	£	£
1. Lantern	1 490	1 490
2. Gear	990	890
3. Cabling and transformers	15 322	12 822
Total:	£17 802	£15 202
		17% saving



Capital cost and annual cost comparison between types of sodium lamps.



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2000 Hamburg 61, Borsteler Chaussee 287

Italy

Società Industriale Vicentina Illuminazione SpA
Casella Postale 104, Vicenza

New Zealand

Thorn Electrical Industries (NZ) Ltd
PO Box 15150, New Lynn, Auckland 7

Norway

Norske Thorn A/S
Tollbugatan 8b, Oslo 1

South Africa

Thorn Lighting (SA) Ltd
PO Box 43075, Industria, Transvaal

Sweden

Svenska Thorn AB
Bällstavägen 30/32, 161 71 Bromma